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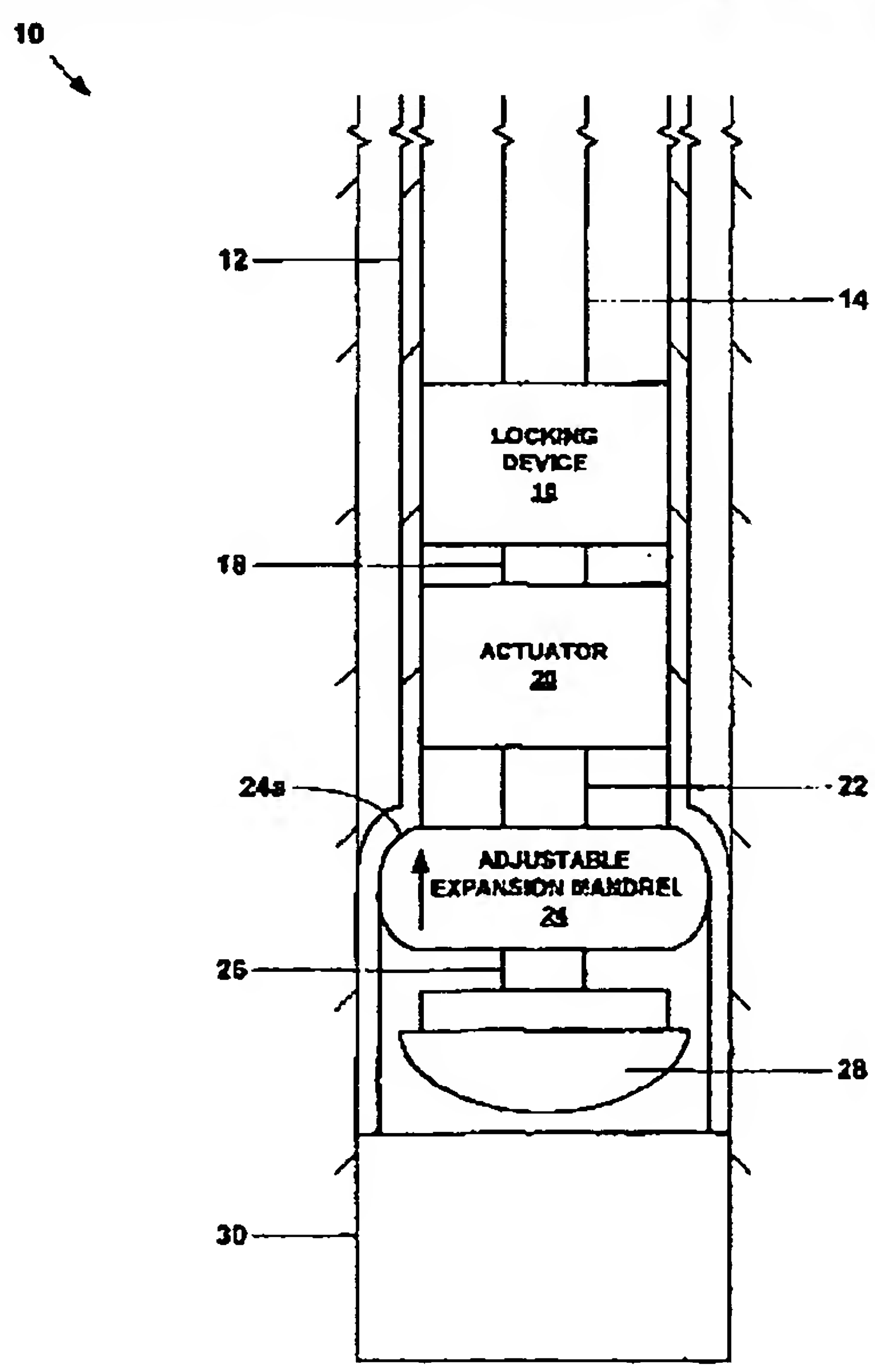
(54) Abstract Title: **Mono diameter wellbore casing**

(57) An apparatus (10) and method for forming a mono diameter wellbore casing (12).



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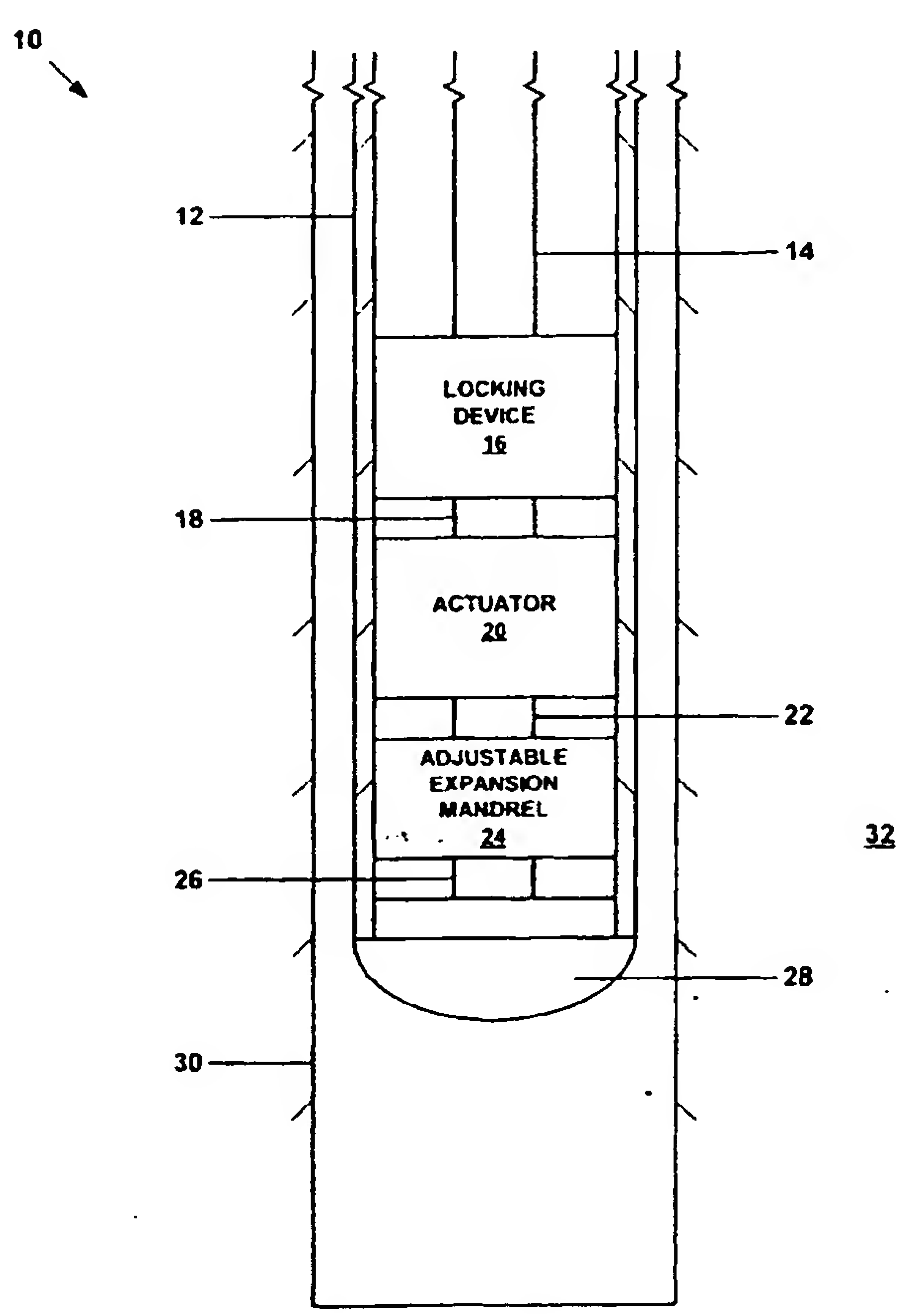
(54) Title: MONO DIAMETER WELLBORE CASING



(57) Abstract: An apparatus and method for forming a mono diameter wellbore casing.

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MONO DIAMETER WELLBORE CASING

Cross Reference To Related Applications

[0001] The present application claims the benefit of the filing dates of: (1) U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/2001, (2) U.S. provisional patent application serial no. 60/339,013, attorney docket no. 88, filed on 11/12/01 (3) U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/2002, (4) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002 the disclosures of which are incorporated herein by reference.

[0002] The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S.

provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/318,021, attorney docket no. 25791.58, filed on 9/7/2001, (29) U.S. provisional patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (30) U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (31) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (32) U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/2001, (33) U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/2001, (34) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (35) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (36) U.S. provisional patent application serial no. 60/346,309, attorney docket no 25791.92, filed on 1/7/2002, (37) U.S. provisional patent application serial no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/2002, (38) U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/2002, (39) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002, (40) U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/2002, (41) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, (42) U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/2002, (43) U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002, (44) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, (45) U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/2002, (46) U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/2002, (47) U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/2002, (48) U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/2002, (49) U.S. provisional patent application serial no, 60/405,610, attorney docket no. 25791.119, filed on 8/23/2002, (50) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/2002, (51) U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/2002, (52) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/2002, (53) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/2002, (54) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/2002, (55) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/2002, (56) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/2002, (57) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.127, filed on 9/20/2002, (58) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.127, filed on 9/20/2002, (58) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on

9/20/2002, (59) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/2002, and (60) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/2002, (61) PCT Patent Application No. PCT/US02_______, attorney docket no. 25791.87.02, filed on 11/11/02 and (62) PCT Patent Application No. PCT/US02_______, attorney docket no. 25791.88.02, filed on 11/11/02 the disclosures of which are incorporated herein by reference.

Background Of The Invention

[0003] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

[0004] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[0005] The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing wellbore casings.

Summary of the Invention

[0010] According to one aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

[0011] According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes

positioning an adjustable expansion mandrel within the expandable tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

[0012] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

[0013] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during radial expansion of the expandable tubular member.

[0014] According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning an adjustable expansion mandrel within the expandable tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to

the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole, and pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

[0015] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole, pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole, and pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

[0016] According to another aspect of the present invention, an apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

[0017] According to another aspect of the present invention, a method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that include positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable

tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole.

[0018] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing within a borehole is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole.

[0019] According to another aspect of the present invention, an apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealing engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during the radial expansion of the expandable tubular member.

[0020] According to another aspect of the present invention, a method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole, and pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

[0021] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing within a borehole is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole, pressuring an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole, and pressuring an interior portion of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the drilled second section of the borehole.

[0022] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension, a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension, an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device. The first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

[0023] According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning first and second adjustable expansion mandrels within the expandable tubular member, supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole, lowering the first adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, and displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0024] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning first and second adjustable expansion mandrels within a first expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole, lowering the first adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member, decreasing

the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member, positioning first and second adjustable expansion mandrels within a second expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member, lowering the first adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, and displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0025] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension, a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension, an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealingly engaging the expandable tubular adapted to define a pressure chamber above the first and second adjustable expansion mandrels during the radial expansion of the expandable tubular member. The first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

[0026] According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning first and second adjustable expansion mandrels within the expandable tubular member, supporting the expandable tubular member and the first and second adjustable expansion mandrels

within the borehole, lowering the first adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member, pressurizing an interior region of the expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member, and pressurizing an interior region of the expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the expandable tubular member above the lower portion of the expandable tubular member by the second adjustable expansion mandrel. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0027] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning first and second adjustable expansion mandrels within a first expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole, lowering the first adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member, pressurizing an interior region of the first expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the first expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member, pressurizing an interior region of the first expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the first expandable tubular member above the lower portion of the first expandable tubular member by the second adjustable expansion mandrel, positioning first and second adjustable expansion mandrels within a second expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first

expandable tubular member, lowering the first adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member, pressurizing an interior region of the second expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the second expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member, and pressurizing an interior region of the second expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the second expandable tubular member above the lower portion of the second expandable tubular member by the second adjustable expansion mandrel. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0028] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a support member, a locking device coupled to the support member and releasably coupled to the expandable tubular member, an adjustable expansion mandrel adapted to be controllably expanded to a larger outside dimension for radial expansion and plastic deformation of the expandable tubular member or collapsed to a smaller outside dimension; and an actuator coupled to the locking member and the adjustable expansion mandrel adapted to displace the adjustable expansion mandrel upwardly through the expandable tubular member to radially expand and plastically deform the expandable tubular member.

[0029] According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole, increasing the size of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

[0030] According to another aspect of the present invention, a method for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing is provided that includes supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole, increasing the size of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic

actuator to radially expand and plastically deform a portion of the expandable tubular member, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

Brief Description of the Drawings

[0031] Fig. 1 is a fragmentary cross-sectional illustration of the placement of an embodiment of an apparatus for radially expanding and plastically deforming a tubular member within a preexisting structure.

[0032] Fig. 2 is a fragmentary cross-sectional illustration of apparatus of Fig. 1 after displacing the adjustable expansion mandrel and the float shoe downwardly out of the end of the expandable tubular member.

[0033] Fig. 3 is a fragmentary cross-sectional illustration of the apparatus of Fig. 2 after expanding the adjustable expansion mandrel.

[0034] Fig. 4 is a fragmentary cross-sectional illustration of the apparatus of Fig. 3 after displacing the adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0035] Fig. 5 is a fragmentary cross-sectional illustration of the apparatus of Fig. 4 after displacing the actuator, locking device, and tubular support member upwardly relative to the adjustable expansion mandrel and the expandable tubular member.

[0036] Fig. 6 is a fragmentary cross-sectional illustration of the apparatus of Fig. 5 after displacing the adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0037] Fig. 6a is a fragmentary cross-sectional illustration of the apparatus of Fig. 6 that include one or more cup seals positioned above the adjustable expansion mandrel for defining an annular pressure chamber above the adjustable expansion mandrel.

[0038] Fig. 7 is a fragmentary cross-sectional illustration of the placement of an embodiment of an apparatus for drilling a borehole and radially expanding and plastically deforming a tubular member within the drilled borehole.

[0039] Fig. 8 is a fragmentary cross-sectional illustration of the apparatus of Fig. 7 after pivoting the drilling elements of the drilling member radially inwardly.

[0040] Fig. 9 is a fragmentary cross-sectional illustration of apparatus of Fig. 8 after displacing the adjustable expansion mandrel and drilling member downwardly out of the end of the expandable tubular member.

[0041] Fig. 10 is a fragmentary cross-sectional illustration of the apparatus of Fig. 9 after expanding the adjustable expansion mandrel.

[0042] Fig. 11 is a fragmentary cross-sectional illustration of the apparatus of Fig. 10 after displacing the adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0043] Fig. 12 is a fragmentary cross-sectional illustration of the apparatus of Fig. 11 after displacing the actuator, locking device, and tubular support member upwardly relative to the adjustable expansion mandrel and the expandable tubular member.

[0044] Fig. 13 is a fragmentary cross-sectional illustration of the apparatus of Fig. 12 after displacing the adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0045] Fig. 14 is a fragmentary cross-sectional illustration of the placement of an embodiment of an apparatus for radially expanding and plastically deforming a tubular member within a preexisting structure.

[0046] Fig. 15 is a fragmentary cross-sectional illustration of the apparatus of Fig. 14 after displacing the lower adjustable expansion mandrel and float shoe downwardly out of the end of the expandable tubular member.

[0047] Fig. 16 is a fragmentary cross-sectional illustration of the apparatus of Fig. 15 after expanding the lower adjustable expansion mandrel.

[0048] Fig. 17 is a fragmentary cross-sectional illustration of the apparatus of Fig. 16 after displacing the lower adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0049] Fig. 18 is a fragmentary cross-sectional illustration of the apparatus of Fig. 17 after displacing the upper and lower adjustable expansion mandrels downwardly relative to the expandable tubular member.

[0050] Fig. 19 is a fragmentary cross-sectional illustration of the apparatus of Fig. 18 after collapsing the lower adjustable expansion mandrel and expanding the upper adjustable expansion mandrel.

[0051] Fig. 20 is a fragmentary cross-sectional illustration of the apparatus of Fig. 19 after displacing the upper adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0052] Fig. 21 is a fragmentary cross-sectional illustration of the apparatus of Fig. 20 after displacing the tubular support member, the locking device, and the actuator upwardly relative to the upper adjustable expansion mandrel and the expandable tubular member.

[0053] Fig. 22 is a fragmentary cross-sectional illustration of the apparatus of Fig. 21 after displacing the upper adjustable expansion mandrel upwardly to radially expand and plastically deform the expandable tubular member.

[0054] Fig. 23 is a fragmentary cross-sectional illustration of a mono diameter wellbore casing formed using one or more of the apparatus of Figs. 1-22.

[0055] Figs. 24a-24k are fragmentary cross sectional illustrations of the placement of an exemplary embodiment of an apparatus for radially expanding and plastically deforming a tubular member within a wellbore that traverses a subterranean formation.

[0056] Fig. 25a-25f are fragmentary cross sectional and perspective illustrations of the expansion cone assembly of the apparatus of Figs. 24a-24k.

[0057] Fig. 25g is a perspective illustration of a float shoe locking dog.

[0058] Fig. 25h is a fragmentary cross sectional illustration of the design and operation of the casing gripper locking dogs.

[0059] Figs. 26a-26k are fragmentary cross sectional illustrations of the apparatus of Figs. 24a-24k after expanding the expansion cone assembly.

[0060] Figs. 27a-27b are a fragmentary cross sectional and perspective illustrations of the expansion cone assembly of the apparatus of Figs. 26a-26k.

[0061] Figs. 28a-28j are fragmentary cross sectional illustrations of the apparatus of Figs. 26a-26k during the upward displacement of the expansion cone assembly by the actuators to radially expand and plastically deform a portion of the casing.

[0062] Figs. 29a-29m are fragmentary cross sectional illustrations of the apparatus of Figs. 28a-28j after the collapse of the expansion cone assembly.

[0063] Fig. 30a-30c are fragmentary cross sectional illustrations of the process for collapsing the expansion cone assembly of the apparatus of Figs. 29a-29m.

[0064] Figs. 31a-31n are fragmentary cross sectional illustrations of the apparatus of Figs. 29a-29m after the plastic deformation and radial expansion of the sealing sleeve and the disengagement of the casing from the locking dogs of the casing lock assembly.

[0065] Figs. 32a-32k are fragmentary cross sectional illustrations of the apparatus of Figs. 31a-31n after setting down the apparatus onto the bottom of the wellbore to open the bypass valve in the shoe and expand the expansion cone assembly.

[0066] Figs. 33a-33p are fragmentary cross sectional illustrations of the apparatus of Figs. 32a-32k during the radial expansion and plastic deformation of the casing.

[0067] Figs. 34a-34l are fragmentary cross sectional illustrations of the apparatus of Figs. 33a-33p during the radial expansion and plastic deformation of a portion of the casing that overlaps within a preexisting wellbore casing within the wellbore.

[0068] Figs. 35a-35l are fragmentary cross sectional illustrations of the apparatus of Figs. 28a-28j during the emergency collapse of the expansion cone assembly.

[0069] Figs. 36a-36b are fragmentary cross sectional illustrations of several exemplary embodiments of the operation of the pressure balance piston.

Detailed Description of the Illustrative Embodiments

[0070] Referring to Fig. 1, an exemplary embodiment of an apparatus 10 for radially expanding and plastically deforming a tubular member 12 includes a tubular support member 14 that extends into

the tubular member that is coupled to an end of a locking device 16 for controllably engaging the tubular member. Another end of the locking device 16 is coupled to a tubular support member 18 that is coupled to an end of an actuator 20. Another end of the actuator 20 is coupled to a tubular support member 22 that is coupled to an end of an adjustable expansion mandrel 24 for radially expanding and plastically deforming the tubular member 12. Another end of the adjustable expansion mandrel 24 is coupled to a tubular support member 26 that is coupled to an end of a float shoe 28 that mates with and is at least partially received within a lower end of the tubular member 12. In an exemplary embodiment, the locking device 16, the tubular support member 18, the actuator 20, the tubular support member 22, the adjustable expansion mandrel 24, and the tubular support member 26 are positioned within the tubular member 12.

[0071] In an exemplary embodiment, the tubular member 12 includes one or more solid and/or slotted tubular members, and one or more of the solid and/or slotted tubular members include resilient sealing members coupled to the exterior surfaces of the solid and/or slotted tubular members for engaging the wellbore 30 and/or one or more preexisting wellbore casings coupled to the wellbore. In an exemplary embodiment, the tubular support members, 14, 18, 22, and 26 define corresponding passages, that may or may not be valveable, for conveying fluidic materials into and/or through the apparatus 10.

[0072] In an exemplary embodiment, the locking device 16 includes one or more conventional controllable locking devices such as, for example, slips and/or dogs for controllably engaging the tubular member 12. In an exemplary embodiment, the locking device 16 is controlled by injecting fluidic materials into the locking device.

[0073] In an exemplary embodiment, the actuator 20 is a conventional actuator that is adapted to displaced the adjustable expansion mandrel 24 and float shoe 28 upwardly or downwardly relative to the actuator.

[0074] In an exemplary embodiment, the adjustable expansion mandrel 24 is a conventional adjustable expansion mandrel that may be expanded to a larger outside dimension or collapsed to a smaller outside dimension and includes external surfaces for engaging the tubular member 12 to thereby radially expand and plastically deform the tubular member when the adjustable expansion mandrel is expanded to the larger outside dimension. In an alternative embodiment, the adjustable expansion mandrel 24 may include a rotary adjustable expansion device such as, for example, the commercially available rotary expansion devices of Weatherford International, Inc. In several alternative embodiments, the cross sectional profile of the adjustable expansion mandrel 24 for radial expansion operations may, for example, be an n-sided shape, where n may vary from 2 to infinity, and the side shapes may include straight line segments, arcuate segments, parabolic segments, and/or hyperbolic segments. In several alternative embodiments, the cross sectional profile of the adjustable expansion mandrel 24 may, for example, be circular, oval, elliptical, and/or multifaceted.

[0075] In an exemplary embodiment, the float shoe 28 is a conventional float shoe.

[0076] In an exemplary embodiment, the apparatus 10 is positioned within a preexisting structure 30 such as, for example, a wellbore that traverses a subterranean formation 32. The wellbore 30 may have any orientation from vertical to horizontal. In several exemplary embodiments, the wellbore 30 may include one or more preexisting solid and/or slotted and/or perforated wellbore casings that may or may not overlap with one another within the wellbore.

[0077] As illustrated in Fig. 2, the adjustable expansion mandrel 24 and the float shoe 28 are then displaced downwardly out of the tubular member 12 by the actuator 20. During the downward displacement of the adjustable expansion mandrel 24 and the float shoe 28 out of the tubular member 12, the tubular member is maintained in a stationary position relative to the tubular support member 14 by the locking device 16.

[0078] As illustrated in Fig. 3, the adjustable expansion mandrel 24 is then expanded to the larger dimension. In several alternative embodiments, the adjustable expansion mandrel 24 may be expanded to the larger dimension by, for example, injecting a fluidic material into the adjustable expansion mandrel and/or by impacting the float shoe 28 on the bottom of the wellbore 30. After expanding the adjustable expansion mandrel 24 to the larger dimension, expansion surfaces 24a are defined on the adjustable expansion mandrel that may include, for example, conical, spherical, elliptical, and/or hyperbolic surfaces for radially expanding and plastically deforming the tubular member 12. In an exemplary embodiment, the expansion surfaces 24a also include means for lubricating the interface between the expansion surfaces and the tubular member 12 during the radial expansion and plastic deformation of the tubular member.

[0079] As illustrated in Fig. 4, the adjustable expansion mandrel 24 is then displaced upwardly by the actuator 20 to thereby radially expand and plastically deform a portion of the tubular member 12. In an exemplary embodiment, during the upward displacement of the adjustable expansion mandrel 24, the tubular member 12 is maintained in a stationary position relative to the tubular support member 14 by the locking device 16. In an exemplary embodiment, the tubular member 12 is radially expanded and plastically deformed into engagement with the wellbore 30 and/or one or more preexisting wellbore casings coupled to the wellbore 30. In an exemplary embodiment, the interface between the expansion surfaces 24a of the adjustable expansion mandrel 24 and the tubular member 12 is not fluid tight in order to facilitate the lubrication of the interface between the expansion surface of the adjustable expansion mandrel and the tubular member.

[0080] As illustrated in Fig. 5, the locking device 16 is then disengaged from the tubular member 12, and the tubular member 12 is supported by the adjustable expansion mandrel 24. The tubular support member 14, the locking device 16, the tubular support member 18, and the actuator 20 are then displaced upwardly relative to the adjustable expansion mandrel 24.

[0081] As illustrated in Fig. 6, the locking device 16 then engages the tubular member 12 to maintain the tubular member in a stationary position relative to the tubular support member 14, and the

adjustable expansion mandrel 24 is displaced upwardly relative by the actuator 20 to radially expand and plastically deform another portion of the tubular member.

[0082] In an exemplary embodiment, the operations of Figs. 5 and 6 are then repeated until the entire length of the tubular member 12 is radially expanded and plastically deformed by the adjustable expansion mandrel 24. In several alternative embodiments, the adjustable expansion mandrel 24 may be collapsed to the smaller dimension prior to the further, or complete, radial expansion and plastic deformation of the tubular member 12.

[0083] In several alternative embodiments, as illustrated in Fig. 6a, the apparatus 10 further includes one or more cup seals 34 that are coupled to the tubular support member 22 and engage the tubular member 12 to define an annular chamber 36 above the adjustable expansion cone 24, and fluidic materials 38 are injected into the tubular member 12 through passages defined within the tubular support member 14, the locking device 16, the tubular support member 18, the actuator 20, the tubular support member 22, the adjustable expansion mandrel 24, the tubular support member 26, and the float shoe 28 to thereby pressurize the annular chamber 36. In this manner, the resulting pressure differential created across the cup seals 34 causes the cup seals to pull the adjustable expansion mandrel 24 upwardly to radially expand and plastically deform the tubular member 12. In several alternative embodiments, the injection of the fluidic material 38 into the tubular member 12 is provided in combination with, or in the alternative to, the upward displacement of the expansion mandrel 24 by the actuator 20. In several alternative embodiments, during the injection of the fluidic material 38, the locking device 16 is disengaged from the tubular member 12.

[0084] Referring to Fig. 7, an alternative embodiment of an apparatus 100 for radially expanding and plastically deforming the tubular member 12 is substantially identical in design and operation to the apparatus 10 with the addition of one or more conventional drilling members 40a-40b that are pivotally coupled to the float shoe 28. During operation of the apparatus 100, the drilling members 40a-40b may be operated to extend the length and/or diameter of the wellbore 30, for example, by rotating the apparatus and/or by injecting fluidic materials into the apparatus to operate the drilling members.

[0085] As illustrated in Fig. 7, in an exemplary embodiment, the apparatus 100 is initially positioned within the preexisting structure 30.

[0086] As illustrated in Fig. 8, in an exemplary embodiment, the drilling members 40a-40b may then be pivoted inwardly in a conventional manner.

[0087] As illustrated in Fig. 9 the adjustable expansion mandrel 24, the float shoe 28, and the drilling members 40a-40b are then displaced downwardly out of the tubular member 12 by the actuator 20. During the downward displacement of the adjustable expansion mandrel 24, the float shoe 28, and the drilling members 40a-40b out of the tubular member 12, the tubular member is maintained in a stationary position relative to the tubular support member 14 by the locking device 16.

[0088] As illustrated in Fig. 10, the adjustable expansion mandrel 24 is then expanded to the larger dimension. In several alternative embodiments, the adjustable expansion mandrel 24 may be expanded

to the larger dimension by, for example, injecting a fluidic material into the adjustable expansion mandrel and/or by impacting the drilling members 40a-40b on the bottom of the wellbore 30. After expanding the adjustable expansion mandrel 24 to the larger dimension, expansion surfaces 24a are defined on the adjustable expansion mandrel that may include, for example, conical, spherical, elliptical, and/or hyperbolic surfaces for radially expanding and plastically deforming the tubular member 12. In an exemplary embodiment, the expansion surfaces 24a also include means for lubricating the interface between the expansion surfaces and the tubular member 12 during the radial expansion and plastic deformation of the tubular member.

[0089] As illustrated in Fig. 11, the adjustable expansion mandrel 24 is then displaced upwardly by the actuator 20 to thereby radially expand and plastically deform a portion of the tubular member 12. In an exemplary embodiment, during the upward displacement of the adjustable expansion mandrel 24, the tubular member 12 is maintained in a stationary position relative to the tubular support member 14 by the locking device 16. In an exemplary embodiment, the tubular member 12 is radially expanded and plastically deformed into engagement with the wellbore 30 and/or one or more preexisting wellbore casings coupled to the wellbore 30. In an exemplary embodiment, the interface between the expansion surfaces 24a of the adjustable expansion mandrel 24 and the tubular member 12 is not fluid tight in order to facilitate the lubrication of the interface between the expansion surface of the adjustable expansion mandrel and the tubular member.

[0090] As illustrated in Fig. 12, the locking device 16 is then disengaged from the tubular member 12, and the tubular member 12 is supported by the adjustable expansion mandrel 24. The tubular support member 14, the locking device 16, the tubular support member 18, and the actuator 20 are then displaced upwardly relative to the adjustable expansion mandrel 24.

[0091] As illustrated in Fig. 13, the locking device 16 then engages the tubular member 12 to maintain the tubular member in a stationary position relative to the tubular support member 14, and the adjustable expansion mandrel 24 is displaced upwardly relative by the actuator 20 to radially expand and plastically deform another portion of the tubular member.

[0092] In an exemplary embodiment, the operations of Figs. 12 and 13 are then repeated until the entire length of the tubular member 12 is radially expanded and plastically deformed by the adjustable expansion mandrel 24. In several alternative embodiments, the adjustable expansion mandrel 24 may be collapsed to the smaller dimension prior to the further, or complete, radial expansion and plastic deformation of the tubular member 12.

[0093] Referring to Fig. 14, an alternative embodiment of an apparatus 200 for radially expanding and plastically deforming the tubular member 12 is substantially identical in design and operation to the apparatus 10 except that the adjustable expansion mandrel 24 has been replaced by an upper adjustable expansion mandrel 202 that is coupled to the tubular support member 22, a tubular support member 204 that is coupled to the upper adjustable expansion mandrel, and a lower adjustable expansion mandrel 206 that is coupled to the tubular support member 204 and the tubular support member 26.

[0094] The upper and lower adjustable expansion mandrels, 202 and 206, may be conventional adjustable expansion mandrels that may be expanded to larger outside dimensions or collapsed to smaller outside dimensions and include external surfaces for engaging the tubular member 12 to thereby radially expand and plastically deform the tubular member when the adjustable expansion mandrels are expanded to the larger outside dimensions. In an alternative embodiment, the upper and/or lower adjustable expansion mandrels, 202 and 206, may include rotary adjustable expansion devices such as, for example, the commercially available rotary expansion devices of Weatherford International, Inc. In an exemplary embodiment, the tubular support member 204 defines a passage, that may, or may not, be valveable, for conveying fluidic materials into and/or through the apparatus 200. In several alternative embodiments, the cross sectional profiles of the adjustable expansion mandrels, 202 and 206, for radial expansion operations may, for example, be n-sided shapes, where n may vary from 2 to infinity, and the side shapes may include straight line segments, arcuate segments, parabolic segments, and/or hyperbolic segments. In several alternative embodiments, the cross sectional profiles of the adjustable expansion mandrels, 202 and 206, may, for example, be circular, oval, elliptical, and/or multifaceted.

[0095] As illustrated in Fig. 14, in an exemplary embodiment, the apparatus 200 is initially positioned within the preexisting structure 30.

[0096] As illustrated in Fig. 15, the lower adjustable expansion mandrel 206 and the float shoe 28 are then displaced downwardly out of the tubular member 12 by the actuator 20. During the downward displacement of the lower adjustable expansion mandrel 206 and the float shoe 28 out of the tubular member 12, the tubular member is maintained in a stationary position relative to the tubular support member 14 by the locking device 16.

[0097] As illustrated in Fig. 16, the lower adjustable expansion mandrel 206 is then expanded to the larger dimension. In several alternative embodiments, the lower adjustable expansion mandrel 206 may be expanded to the larger dimension by; for example, injecting a fluidic material into the lower adjustable expansion mandrel and/or by impacting the float shoe 28 on the bottom of the wellbore 30. After expanding the lower adjustable expansion mandrel 206 to the larger dimension, expansion surfaces 206a are defined on the lower adjustable expansion mandrel that may include, for example, conical, spherical, elliptical, and/or hyperbolic surfaces for radially expanding and plastically deforming the tubular member 12. In an exemplary embodiment, the expansion surfaces 206a also include means for lubricating the interface between the expansion surfaces and the tubular member 12 during the radial expansion and plastic deformation of the tubular member.

[0098] As illustrated in Fig. 17, the lower adjustable expansion mandrel 206 is then displaced upwardly by the actuator 20 to thereby radially expand and plastically deform a portion 12a of the tubular member 12. In an exemplary embodiment, during the upward displacement of the lower adjustable expansion mandrel 206, the tubular member 12 is maintained in a stationary position relative to the tubular support member 14 by the locking device 16. In an exemplary embodiment, the tubular

member 12 is radially expanded and plastically deformed into engagement with the wellbore 30 and/or one or more preexisting wellbore casings coupled to the wellbore 30. In an exemplary embodiment, the interface between the expansion surfaces 206a of the lower adjustable expansion mandrel 206 and the tubular member 12 is not fluid tight in order to facilitate the lubrication of the interface between the expansion surface of the lower adjustable expansion mandrel and the tubular member. In an exemplary embodiment, the expansion surfaces 206a also include means for lubricating the interface between the expansion surfaces and the tubular member 12 during the radial expansion and plastic deformation of the tubular member.

[0099] As illustrated in Fig. 18, the upper and lower adjustable expansion mandrels, 202 and 206, and the float shoe 28 are then displaced downwardly by the actuator 20. During the downward displacement of the upper and lower adjustable expansion mandrels, 202 and 206, and the float shoe 28, the tubular member is maintained in a stationary position relative to the tubular support member 14 by the locking device 16.

[0100] As illustrated in Fig. 19, the upper adjustable expansion mandrel 202 is then expanded to the larger dimension and the lower adjustable expansion mandrel 206 is collapsed to the smaller dimension. In an exemplary embodiment, the larger dimension of the upper adjustable expansion mandrel 202 is less than the larger dimension of the lower adjustable expansion mandrel 206. In several alternative embodiments, the upper adjustable expansion mandrel 202 may be expanded to the larger dimension and the lower adjustable expansion mandrel 206 may be collapsed to the smaller dimension by, for example, injecting fluidic material into the upper and/or adjustable expansion mandrel and/or by impacting the float shoe 28 on the bottom of the wellbore 30. After expanding the upper adjustable expansion mandrel 202 to the larger dimension, expansion surfaces 202a are defined on the upper adjustable expansion mandrel that may include, for example, conical, spherical, elliptical, and/or hyperbolic surfaces for radially expanding and plastically deforming the tubular member 12. In an exemplary embodiment, the expansion surfaces 202a also include means for lubricating the interface between the expansion surfaces and the tubular member 12 during the radial expansion and plastic deformation of the tubular member.

[0101] As illustrated in Fig. 20, the upper adjustable expansion mandrel 202 is then displaced upwardly by the actuator 20 to thereby radially expand and plastically deform a portion 12b of the tubular member 12 above the portion 12a of the tubular member. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed portion 12a of the tubular member 12 is greater than the inside diameter of the radially expanded and plastically deformed portion 12b of the tubular member. In an exemplary embodiment, during the upward displacement of the upper adjustable expansion mandrel 202, the tubular member 12 is maintained in a stationary position relative to the tubular support member 14 by the locking device 16. In an exemplary embodiment, the tubular member 12 is radially expanded and plastically deformed into engagement with the wellbore 30 and/or one or more preexisting wellbore casings coupled to the wellbore 30. In an exemplary embodiment, the

interface between the expansion surfaces 202a of the upper adjustable expansion mandrel 202 and the tubular member 12 is not fluid tight in order to facilitate the lubrication of the interface between the expansion surface of the upper adjustable expansion mandrel and the tubular member.

[0102] As illustrated in Fig. 21, the locking device 16 is then disengaged from the tubular member 12, and the tubular member 12 is supported by the upper adjustable expansion mandrel 202. The tubular support member 14, the locking device 16, the tubular support member 18, and the actuator 20 are then displaced upwardly relative to the upper adjustable expansion mandrel 202 and the tubular member 12.

[0103] As illustrated in Fig. 22, the locking device 16 then engages the tubular member 12 to maintain the tubular member in a stationary position relative to the tubular support member 14, and the upper adjustable expansion mandrel 202 is displaced upwardly relative by the actuator 20 to radially expand and plastically deform the portion 12b of the tubular member.

[0104] In an exemplary embodiment, the operations of Figs. 21 and 22 are then repeated until the remaining length of the portion 12b of the tubular member 12 is radially expanded and plastically deformed by the upper adjustable expansion mandrel 202. In several alternative embodiments, the upper adjustable expansion mandrel 202 may be collapsed to the smaller dimension prior to the further, or complete, radial expansion and plastic deformation of the tubular member 12.

[0105] Referring to Fig. 23, in an exemplary embodiment, the method and apparatus of one or more of Figs. 1-22 are repeated to provide a mono diameter wellbore casing 300 within a borehole 302 that traverses a subterranean formation 304 by successively overlapping and radially expanding and plastically deforming wellbore casing 306a-306d within the wellbore. In this manner, a wellbore casing 300 is provided that defines an interior passage having a substantially constant cross sectional area throughout its length. In several alternative embodiments, the cross section of the wellbore casing 300 may be, for example, square, rectangular, elliptical, oval, circular and/or faceted.

[0106] Referring to Figs. 24a-24k, an exemplary embodiment of an apparatus 400 for radially expanding and plastically deforming a tubular member includes a tubular support member 402 that defines a longitudinal passage 402a that is threadably coupled to and received within an end of a tool joint adaptor 404 that defines a longitudinal passage 404a and radial passages 404b and 404c.

[0107] The other end of the tool joint adaptor 404 receives and is threadably coupled to an end of a gripper upper mandrel 406 that defines a longitudinal passage 406a, external radial mounting holes, 406b and 406c, an external annular recess 406d, an external annular recess 406e, hydraulic port 406f, an internal annular recess 406g, hydraulic port 406h, external radial mounting holes, 406i and 406j, and includes a flange 406k, and a flange 406l. Torsional locking pins, 408a and 408b, are coupled to the external radial mounting holes, 406b and 406c, respectively, of the gripper upper mandrel 406 and received within the radial passages, 404b and 404c, respectively, of the tool joint adaptor 404.

[0108] A spring retainer sleeve 410 that includes a flange 410a receives and is threadably coupled to the gripper upper mandrel 406 between an end face of the tool joint adaptor 404 and the flange 406k

of the gripper upper mandrel. A bypass valve body 412 receives and is movably coupled to the gripper upper mandrel 406 that defines radial passages, 412a and 412b, and an internal annular recess 412c includes a flange 412d.

[0109] An end of a spring cover 414 receives and is movably coupled to the spring retainer sleeve 410 that defines an internal annular recess 414a. The other end of the spring cover 414 receives and is threadably coupled to an end of the bypass valve body 412. A spring guide 416, a spring 418, and a spring guide 420 are positioned within an annular chamber 422 defined between the spring cover 414 and the flange 406k of the gripper upper mandrel 406. Furthermore, an end of the spring guide 416 abuts an end face of the spring retainer sleeve 410.

[0110] Casing gripper locking dogs, 424a and 424b, are received and pivotally mounted within the radial passages, 412a and 412b, respectively, of the bypass valve body 412. An end of each of the casing gripper locking dogs, 424a and 424b, engage and are received within the outer annular recess 406d of the gripper upper mandrel 406. An end of a debris trap 426 receives and is threadably coupled to an end of the bypass valve body 412, and the other end of the debris trap receives and is movably coupled to the flange 406l of the gripper upper mandrel 406.

[0111] An end of a gripper body 428 receives and is threadably coupled to an end of the gripper upper mandrel 406 that defines a longitudinal passage 428a, radial passages, 428b and 428c, radial slip mounting passages, 428d-428m, and radial passages, 428n and 428o, includes a flange 428p.

[0112] Hydraulic slip pistons 432a-432j are movably mounted with the radial slip mounting passages 428d-428m, respectively, for movement in the radial direction. Retainers 434a-434j are coupled to the exterior of the flange 428p of the gripper body 428 for limiting the outward radial movement of the hydraulic slip pistons 432a-432j, respectively, and springs 436a-436j are positioned within the radial slip mounting passages, 428d-428m, respectively, of the gripper body between the hydraulic slip pistons, 432a-432j, and the retainers, 434a-434j, respectively. During operation of the apparatus 400, pressurization of the radial slip mounting passages, 428d-428m, displaces the hydraulic slip pistons, 432a-432j, respectively, radially outwardly and compresses the springs, 436a-436j, respectively, and during depressurization of the radial slip mounting passages, 428d-428m, springs, 436a-436j, respectively, displace the hydraulic slip pistons, 432a-432j, inwardly. In an exemplary embodiment, displacement of the hydraulic slip pistons 432a-432j radially outwardly permits at least portions of the hydraulic slip pistons to engage and grip an outer tubular member.

[0113] Torsional locking pins, 438a and 438b, are coupled to the external radial mounting holes, 406i and 406j, respectively, of the gripper upper mandrel 406 and received within the radial passages, 428b and 428c, respectively, of the gripper body 428.

[0114] An end of a gripper body 440 receives and is threadably coupled to an end of the gripper body 428 that defines a longitudinal passage 440a, radial passages, 440b and 440c, radial slip mounting passages, 440d-440m, and radial passages, 440n and 440o, includes a flange 440p.

[0115] Hydraulic slip pistons 442a-442j are movably mounted with the radial slip mounting passages 440d-440m, respectively, for movement in the radial direction. Retainers 444a-444j are coupled to the exterior of the flange 440p of the gripper body 440 for limiting the outward radial movement of the hydraulic slip pistons 442a-442j, respectively, and springs 446a-446j are positioned within the radial slip mounting passages, 440d-440m, respectively, of the gripper body between the hydraulic slip pistons, 442a-442j, and the retainers, 444a-444j, respectively. During operation of the apparatus 400, pressurization of the radial slip mounting passages, 440d-440m, displaces the hydraulic slip pistons, 442a-442j, respectively, radially outwardly and compresses the springs, 446a-446j, respectively, and during depressurization of the radial slip mounting passages, 440d-440m, the springs, 446a-446j, respectively, displace the hydraulic slip pistons, 442a-442j, radially inward. In an exemplary embodiment, displacement of the hydraulic slip pistons 442a-442j radially outwardly permits at least portions of the hydraulic slip pistons to engage and grip an outer tubular member.

[0116] Torsional locking pins, 448a and 448b, are coupled to the external radial mounting holes, 428n and 428o, respectively, of the gripper body 428 and received within the radial passages, 440b and 440c, respectively, of the gripper body 440.

[0117] An end of a tool joint adaptor 450 that defines a longitudinal passage 450a, radial passages, 450b and 450c, and an inner annular recess 450d, receives and is threadably coupled to an end of the gripper body 440. Torsional locking pins, 452a and 452b, are coupled to the external radial mounting holes, 440n and 440o, respectively, of the gripper body 428 and received within the radial passages, 450b and 450c, respectively, of the tool joint adaptor 450.

[0118] A bypass tube 454 that defines a longitudinal passage 454a is received within the longitudinal passages, 406a, 428a, 440a, and 450a, of the gripper upper mandrel 406, the gripper body 428, the gripper body 440, and the tool joint adaptor 450, respectively, is coupled to the recess 406g of the gripper upper mandrel at one end and is coupled to the recess 450d of the tool joint adaptor at the other end.

[0119] An end of a cross over adaptor 456 that defines a longitudinal passage 456a receives and is threadably coupled to an end of the tool joint adaptor 450. The other end of the cross over adaptor 456 is received within and is coupled to an end of a tool joint adaptor 458 that defines a longitudinal passage 458a and external radial mounting holes, 458b and 458c.

[0120] An end of a positive casing locking body 460 that defines a tapered longitudinal passage 460a and radial passages, 460b and 460c, receives and is threadably coupled to the other end of the tool joint adaptor 458. Torsional locking pins, 462a and 462b, are coupled to the external radial mounting holes, 458b and 458c, respectively, of the tool joint adaptor 458 and received within the radial passages, 460b and 460c, respectively, of the positive casing locking body 460.

[0121] An end of a positive casing locking dog 464 mates with, is received within, and is coupled to the other end of the positive casing locking body 460 that includes internal flanges, 464a and 464b, and an external flange 464c. In an exemplary embodiment, the external flange 464c of the positive

casing locking dog 464 includes an ribbed external surface 464d that engages and locks onto a ribbed internal surface 466a of a positive casing locking collar 466.

[0122] One end of the positive casing locking collar 466 is threadably coupled to a casing 468 and the other end of the positive casing locking collar is threadably coupled to a casing 470 that defines radial mounting holes, 470a and 470b, at a lower end thereof. In this manner, the casings, 468 and 470, are also engaged by and locked onto the positive casing locking dog 464.

[0123] The other end of the positive casing locking dog 464 mates with, is received within, and is coupled to an end of a positive casing locking body 472 that defines a tapered longitudinal passage 472a and radial passages, 472b and 472c. The other end of the positive casing locking body 472 receives, mates with, and is coupled to an end of a casing lock barrel adaptor 474 that defines external radial mounting holes, 474a and 474b, and external radial mounting holes, 474c and 474d. Torsional locking pins, 475a and 475b, are coupled to the external radial mounting holes, 474a and 474b, respectively, of the casing lock barrel adaptor 474 and received within the radial passages, 472b and 472c, respectively, of the positive casing locking body 472.

[0124] An end of a positive casing lock releasing mandrel 476 that defines a longitudinal passage 476a, an external annular recess 476b, an external annular recess 476c, an external annular recess 476d, and an external annular recessed end portion 476e, is received within and movably coupled to an end of the tool joint adaptor 458. The middle portion of the positive casing lock releasing mandrel 476 is received within and mates with the internal flanges, 464a and 464b, of the positive casing locking dogs 464. The other end of the positive casing lock releasing mandrel 476 is received within and is movably coupled to the end of the casing lock barrel adaptor 474, and the external annular recessed portion 476e of the positive casing lock releasing mandrel is threadably coupled to and received within an end of a positive casing lock lower mandrel 478 that defines a longitudinal passage 478a, external radial mounting holes, 478b and 478c, and an external annular recessed end portion 478d.

[0125] A shear pin ring 480 that defines radial passages, 480a and 480b, receives and mates with the positive casing lock lower mandrel 478. Shear pins, 482a and 482b, are coupled to the external radial mounting holes, 478b and 478c, respectively, of the positive casing lock lower mandrel 478 and are received within the radial passages, 480a and 480b, respectively, of the shear pin ring 480.

[0126] An end of an actuator barrel 484 that defines a longitudinal passage 484a, radial passages, 484b and 484c, and radial passages, 484d and 484e, is threadably coupled to an end of the casing lock barrel adaptor 474. Torsional locking pins, 486a and 486b, are coupled to the external radial mounting holes, 474c and 474d, respectively, of the casing lock barrel adaptor and are received within the radial passages, 484b and 484c, respectively, of the actuator barrel.

[0127] The other end of the actuator barrel 484 is threadably coupled to an end of a barrel connector 486 that defines an internal annular recess 486a, external radial mounting holes, 486b and 486c, radial passages, 486d and 486e, and external radial mounting holes, 486f and 486g. A sealing cartridge 488 is received within and coupled to the internal annular recess 486a of the barrel connector

486 for fluidicly sealing the interface between the barrel connector and the sealing cartridge. Torsional locking pins, 490a and 490b, are coupled to and mounted within the external radial mounting holes, 486b and 486c, respectively, of the barrel connector 486 and received within the radial passages, 484d and 484e, of the actuator barrel 484.

[0128] The other end of the barrel connector 486 is threadably coupled to an end of an actuator barrel 492 that defines a longitudinal passage 492a, radial passages, 492b and 492c, and radial passages, 492d and 492e. Torsional locking pins, 494a and 494b, are coupled to and mounted within the external radial mounting holes, 486f and 486g, respectively, of the barrel connector 486 and received within the radial passages, 492b and 492c, of the actuator barrel 492. The other end of the actuator barrel 492 is threadably coupled to an end of a barrel connector 496 that defines an internal annular recess 496a, external radial mounting holes, 496b and 496c, radial passages, 496d and 496e, and external radial mounting holes, 496f and 496g. A sealing cartridge 498 is received within and coupled to the internal annular recess 496a of the barrel connector 496 for fluidicly sealing the interface between the barrel connector and the sealing cartridge. Torsional locking pins, 500a and 500b, are coupled to and mounted within the external radial mounting holes, 496b and 496c, respectively, of the barrel connector 496 and received within the radial passages, 492d and 492e, of the actuator barrel 492.

[0129] The end of the barrel connector 496 is threadably coupled to an end of an actuator barrel 502 that defines a longitudinal passage 502a, radial passages, 502b and 502c, and radial passages, 502d and 502e. Torsional locking pins, 504a and 504b, are coupled to and mounted within the external radial mounting holes, 496f and 496g, respectively, of the barrel connector 496 and received within the radial passages, 502b and 502c, of the actuator barrel 502. The other end of the actuator barrel 502 is threadably coupled to an end of a barrel connector 506 that defines an internal annular recess 506a, external radial mounting holes, 506b and 506c, radial passages, 506d and 506e, and external radial mounting holes, 506f and 506g. Torsional locking pins, 508a and 508b, are coupled to and mounted within the external radial mounting holes, 506b and 506c, respectively, of the barrel connector 506 and received within the radial passages, 502d and 502e, of the actuator barrel 502. A sealing cartridge 510 is received within and coupled to the internal annular recess 506a of the barrel connector 506 for fluidicly sealing the interface between the barrel connector and the sealing cartridge.

[0130] The other end of the barrel connector 506 is threadably coupled to an end of an actuator barrel 512 that defines a longitudinal passage 512a, radial passages, 512b and 512c, and radial passages, 512d and 512e. Torsional locking pins, 514a and 514b, are coupled to and mounted within the external radial mounting holes, 506f and 506g, respectively, of the barrel connector 506 and received within the radial passages, 512b and 512c, of the actuator barrel 512. The other end of the actuator barrel 512 is threadably coupled to an end of a lower stop 516 that defines an internal annular recess 516a, external radial mounting holes, 516b and 516c, and an internal annular recess 516d that includes one or more circumferentially spaced apart locking teeth 516e at one end and one or more circumferentially spaced apart locking teeth 516f at the other end. A sealing cartridge 518 is received within and coupled to the

internal annular recess 516a of the barrel connector 516 for fluidicly sealing the interface between the barrel connector and the sealing cartridge. Torsional locking pins, 520a and 520b, are coupled to and mounted within the external radial mounting holes, 516b and 516c, respectively, of the barrel connector 516 and received within the radial passages, 512d and 512e, of the actuator barrel 512.

[0131] A connector tube 522 that defines a longitudinal passage 522a is received within and sealingly and movably engages the interior surface of the sealing cartridge 488 mounted within the annular recess 486a of the barrel connector 486. In this manner, during longitudinal displacement of the connector tube 522 relative to the barrel connector 486, a fluidic seal is maintained between the exterior surface of the connector tube and the interior surface of the barrel connector. An end of the connector tube 522 is received within and is threadably coupled to an end of dart/ball guide 524 that defines a tapered passage 524a at the other end.

[0132] The other end of the connector tube 522 is received within and threadably coupled to an end of a piston 526 that defines a longitudinal passage 526a and radial passages, 526b and 526c, that includes a flange 526d at one end. A sealing cartridge 528 is mounted onto and sealingly coupled to the exterior of the piston 526 proximate the flange 526d. The sealing cartridge 528 also mates with and sealingly engages the interior surface of the actuator barrel 492. In this manner, during longitudinal displacement of the piston 526 relative to the actuator barrel 492, a fluidic seal is maintained between the exterior surface of the piston and the interior surface of the actuator barrel.

[0133] The other end of the piston 526 receives and is threadably coupled to an end of a connector tube 529 that defines a longitudinal passage 528a. The connector tube 529 is received within and sealingly and movably engages the interior surface of the sealing cartridge 498 mounted within the annular recess 496a of the barrel connector 496. In this manner, during longitudinal displacement of the connector tube 529 relative to the barrel connector 496, a fluidic seal is maintained between the exterior surface of the connector tube and the interior surface of the barrel connector.

[0134] The other end of the connector tube 529 is received within and threadably coupled to an end of a piston 530 that defines a longitudinal passage 530a and radial passages, 530b and 530c, that includes a flange 530d at one end. A sealing cartridge 532 is mounted onto and sealingly coupled to the exterior of the piston 530 proximate the flange 530d. The sealing cartridge 532 also mates with and sealingly engages the interior surface of the actuator barrel 502. In this manner, during longitudinal displacement of the piston 530 relative to the actuator barrel 502, a fluidic seal is maintained between the exterior surface of the piston and the interior surface of the actuator barrel.

[0135] The other end of the piston 530 receives and is threadably coupled to an end of a connector tube 534 that defines a longitudinal passage 534a. The connector tube 534 is received within and sealingly and movably engages the interior surface of the sealing cartridge 510 mounted within the annular recess 506a of the barrel connector 506. In this manner, during longitudinal displacement of the connector tube 534 relative to the barrel connector 506, a fluidic seal is maintained between the exterior surface of the connector tube and the interior surface of the barrel connector.

[0136] The other end of the connector tube 534 is received within and threadably coupled to an end of a piston 536 that defines a longitudinal passage 536a, radial passages, 536b and 536c, and external radial mounting holes, 536d and 536e, that includes a flange 536f at one end. A sealing cartridge 538 is mounted onto and sealingly coupled to the exterior of the piston 536 proximate the flange 536d. The sealing cartridge 538 also mates with and sealingly engages the interior surface of the actuator barrel 512. In this manner, during longitudinal displacement of the piston 536 relative to the actuator barrel 512, a fluidic seal is maintained between the exterior surface of the piston and the interior surface of the actuator barrel.

[0137] The other end of the piston 536 is received within and threadably coupled to an end of a lock nut 540 that defines radial passages, 540a and 540b, and includes one or more circumferentially spaced apart locking teeth 540c at the other end for engaging the circumferentially spaced apart locking teeth 516e of the lower stop 516.

[0138] A threaded bushing 542 is received within and threadably coupled to the circumferentially spaced apart locking teeth 540c of the lock nut 540. An end of a connector tube 544 that defines a longitudinal passage 544a is received within and is threadably coupled to the threaded bushing 542. A sealing sleeve 546 is received within and is threadably coupled to adjacent ends of the piston 536 and the connector tube 544 for fluidicly sealing the interface between the end of the piston and the end of the connector tube. Torsional locking pins, 548a and 548b, are mounted within and coupled to the external radial mounting holes, 536d and 536e, respectively, of the piston 536 that are received within the radial passages, 540a and 540b, of the stop nut 540.

[0139] The connector tube 544 is received within and sealingly and movably engages the interior surface of the sealing cartridge 518 mounted within the annular recess 516a of the barrel connector 516. In this manner, during longitudinal displacement of the connector tube 544 relative to the barrel connector 516, a fluidic seal is maintained between the exterior surface of the connector tube and the interior surface of the barrel connector.

[0140] The other end of the connector tube 544 is received within and is threadably coupled to a threaded bushing 550. The threaded bushing 550 is received within and threadably coupled to a lock nut 552 that defines radial passages, 552a and 552b, and includes one or more circumferentially spaced apart locking teeth 552c at one end for engaging the circumferentially spaced apart locking teeth 516f of the lower stop 516. The other end of the lock nut 552 receives and is threadably coupled to an end of tool joint adaptor 554 that defines a longitudinal passage 554a, external radial mounting holes, 554b and 554c. Torsional locking pins, 556a and 556b, are mounted within and coupled to the external radial mounting holes, 554b and 554c, respectively, of the tool joint adaptor 554 that are received within the radial passages, 552a and 552b, of the stop nut 552. A sealing sleeve 558 is received within and is threadably coupled to adjacent ends of the connector tube 544 and the tool joint adaptor 554 for fluidicly sealing the interface between the end of the connector tube and the end of the tool joint adaptor.

[0141] The other end of the tool joint adaptor 554 is received within and threadably coupled to an end of a tool joint adaptor 560 that defines a longitudinal passage 560a. A torsion plate 562 is received within and threadably coupled to the other end of the tool joint adaptor 560 that defines a longitudinal passage 562a and includes one or more circumferentially spaced apart locking teeth 562b at one end. An end of an upper bushing 564 is also received within and threadably coupled to the other end of the tool joint adaptor 560 proximate the torsion plate 562 that receives and is threadably coupled to an end of a cup mandrel 566 that defines a longitudinal passage 566a and includes a plurality of circumferentially spaced apart locking teeth 566b at one end for engaging the circumferentially spaced apart locking teeth 562b of the torsion plate 562. The end of the cup mandrel 566 is further positioned proximate an end face of the torsion plate 562.

[0142] A thimble 568 is mounted on and is threadably coupled to the cup mandrel 566 proximate an end face of the upper bushing 564. An inner thimble 570 is mounted on and is threadably coupled to the cup mandrel 566 proximate an end of the thimble 568, and one end of the inner thimble is received within and mates with the end of the thimble. A resilient packer cup 572 is mounted on and sealingly engages the cup mandrel 566 proximate an end of the inner thimble 570, and one end of the packer cup is received within and mates with the end of the inner thimble. A packer cup backup ring 574 is mounted on the inner thimble 570 proximate an end face of the thimble 568, and an end of the packer cup backup ring 574 receives and mates with the packer cup 572. A spacer 576 is mounted on and threadably engages the cup mandrel 566 proximate an end face of the packer cup 572.

[0143] A thimble 578 is mounted on and is threadably coupled to the cup mandrel 566 proximate an end of the spacer 576. An inner thimble 580 is mounted on and is threadably coupled to the cup mandrel 566 proximate an end of the thimble 578, and one end of the inner thimble is received within and mates with the end of the thimble. A resilient packer cup 582 is mounted on and sealingly engages the cup mandrel 566 proximate an end of the inner thimble 580, and one end of the packer cup is received within and mates with the end of the inner thimble. A packer cup backup ring 584 is mounted on the inner thimble 580 proximate an end face of the thimble 578, and an end of the packer cup backup ring 584 receives and mates with the packer cup 582. An adjustable spacer 586 is mounted on and threadably engages the cup mandrel 566 proximate an end face of the packer cup 582.

[0144] An end of a cone mandrel 588 that defines a longitudinal passage 588a, an external lock ring groove 588b, an external lock ring groove 588c, an external lock ring groove 588d, an external lock ring groove 588e, radial passages, 588f and 588g, and locking dog grooves 588h receives and is threadably coupled to an end of the cup mandrel 566. A shear pin bushing 590 that defines external radial mounting holes, 590a and 590b, at one end and an annular recess 590c at another end and includes circumferentially spaced apart locking teeth 590d at the other end is mounted on and is movably coupled to the cone mandrel 588. Torsional shear pins, 592a and 592b, are mounted within and coupled to the external radial mounting holes, 590a and 590b, respectively, of the shear pin bushing 590 and received within the radial passages, 470a and 470b, respectively, of the end of the casing 470.

In this manner, torque loads may be transmitted between the casing 470 and the shear pin bushing 590. A resilient lock ring 594 is retained in the external lock ring groove 588b of the cone mandrel and received within the internal annular recess 590c at the end of the shear pin bushing 590.

[0145] Referring to Figs. 24j, 25a, and 25b, an upper cone retainer 596 receives, mates with, and is coupled to the end of the shear pin bushing 590 that includes an internal flange 596a and an internal upper pivot point flange 596b. An end of an upper cam 598 includes a tubular base 598a that mates with, receives, and is movably coupled to the cone mandrel 588. The tubular base 598a of the upper cam 598 further includes an external flange 598b that is received within and mates with the upper cone retainer 596 proximate the internal flange 596a of the upper cone retainer and a plurality of circumferentially spaced apart locking teeth 598c that engage the circumferentially spaced apart locking teeth 590d of the end of the shear pin bushing 590. In this manner, the upper cam 598 is retained within the upper cone retainer 596 and torque loads may be transmitted between the upper cam and the shear pin bushing 590.

[0146] Referring to Figs. 25b and 25c, the upper cam 598 further includes a plurality of circumferentially spaced apart cam arms 598d that extend from the tubular base 598a in the longitudinal direction that mate with, receive, and are movably coupled to the cone mandrel 588. Each cam arm 598d includes an inner surface 598da that is an arcuate cylindrical segment, a first outer surface 598db that is an arcuate cylindrical segment, a second outer surface 598dc that is an arcuate conical segment, and a third outer surface 598dd that is an arcuate cylindrical segment. In an exemplary embodiment, each of the cam arms 598d are identical.

[0147] Referring to Figs. 24j, 25a, and 25d, a plurality of circumferentialy spaced apart upper cone segments 600 are interleaved among the cam arms 598d of the upper cam 598. In an exemplary embodiment, each upper cone segment 600 includes a first outer surface 600a that defines a hinge groove 600b, a second outer surface 600c, a third outer surface 600d, a fourth outer surface 600e, a first inner surface 600f, a second inner surface 600g, a third inner surface 600h, and a fourth inner surface 600i. In an exemplary embodiment, the first outer surface 600a, the second outer surface 600c, the fourth outer surface 600e, the first inner surface 600f, the second inner surface 600g, and the fourth inner surface 600i are arcuate cylindrical segments. In an exemplary embodiment, the third outer surface 600d is an arcuate spherical segment. In an exemplary embodiment, the third inner surface 600h is an arcuate conical segment. In an exemplary embodiment, each of the upper cone segments 600 are identical. In an exemplary embodiment, the hinge grooves 600b of the upper cone segments 600 receive and mate with the pivot point 596b of the upper cone retainer 596. In this manner, the upper cone segments 600 are pivotally coupled to the upper cone retainer 596.

[0148] Referring to Figs. 24j, 25a, and 25e, a plurality of circumferentially spaced apart lower cone segments 602 overlap with and are interleaved among the upper cone segments 600. In an exemplary embodiment, each lower cone segment 602 includes a first outer surface 602a that defines a hinge groove 602b, a second outer surface 602c, a third outer surface 602d, a fourth outer surface 602e,

a first inner surface 602f, a second inner surface 602g, a third inner surface 602h, and a fourth inner surface 602i. In an exemplary embodiment, the first outer surface 602a, the second outer surface 602c, the fourth outer surface 602e, the first inner surface 602f, the second inner surface 602g, and the fourth inner surface 602i are arcuate cylindrical segments. In an exemplary embodiment, the third outer surface 602d is an arcuate spherical segment. In an exemplary embodiment, the third inner surface 602h is an arcuate conical segment. In an exemplary embodiment, each of the lower cone segments 602 are identical.

[0149] Referring to Figs. 24j, 25a, 25b, and 25f, a plurality of circumferentially spaced apart cam arms 604a that extend in the longitudinal direction from a tubular base 604b of a lower cam 604 overlap and are interleaved among the circumferentially spaced apart cam arms 598d of the upper cam 598 and mate with, receive, and are movably coupled to the cone mandrel 588. The tubular base 604b of the lower cam 604 mates with, receives, and is movably coupled to the cone mandrel 588 and includes an external flange 604c and a plurality of circumferentially spaced apart locking teeth 604d. Each cam arm 604a includes an inner surface 604aa that is an arcuate cylindrical segment, a first outer surface 604ab that is an arcuate cylindrical segment, a second outer surface 604ac that is an arcuate conical segment, and a third outer surface 604ad that is an arcuate cylindrical segment. In an exemplary embodiment, each of the cam arms 604a are identical.

[0150] An end of a lower cone retainer 606 includes an inner pivot point flange 606a that mates with and is received within the hinge grooves 602b of the lower cone segments 602. In this manner, the lower cone segments 602 are pivotally coupled to the lower cone retainer 606. The lower cone retainer 606 further includes an inner flange 606b that mates with and retains the external flange 604c of the lower cam 604. In this manner, the lower cam 604 is retained within the lower cone retainer 606.

[0151] The other end of the lower cone retainer 606 receives and is threadably coupled to an end of a release housing 608 that defines a radial passage 608a at another end and includes a plurality of circumferentially spaced apart locking teeth 608b at the end of the release housing for engaging the circumferentially spaced apart locking teeth 604d of the lower cam 604. In this manner, torque loads may be transmitted between the release housing 608 and the lower cam 604. An end of a lower mandrel 610 that defines a longitudinal passage 610a, an external radial mounting hole 610b, and radial passages 610c is received within, mates with, and is movably coupled to the other end of the release housing 608. A torsion locking pin 612 is mounted within and coupled to the external radial mounting hole 610b of the lower mandrel 610 and received within the radial passage 608a of the release housing 608. In this manner, longitudinal and torque loads may be transmitted between the release housing 608 and the lower mandrel 610.

[0152] An end of a locking dog retainer sleeve 614 that defines an inner annular recess 614a at one end and includes a plurality of circumferentially spaced apart locking teeth 614b at one end for engaging the locking teeth 604d of the lower cam 604 is received within and threadably coupled to an end of the lower mandrel 610. The locking dog retainer sleeve 614 is also positioned between and

movably coupled to the release housing 608 and the cone mandrel 588. Locking dogs 616 are received within the inner annular recess 614a of the locking dog retainer sleeve 614 that releasably engage the locking dog grooves 588h provided in the exterior surface of the cone mandrel 588. In this manner, the locking dogs 616 releasably limit the longitudinal displacement of the lower cone segments 602, lower cam 604, and the lower cone retainer 606 relative to the cone mandrel 588.

[0153] A locking ring retainer 618 is received within and is threadably coupled to an end of the lower mandrel 610 that defines an inner annular recess 618a for retaining a resilient locking ring 620 within the lock ring groove 588d of the cone mandrel 588. The locking ring retainer 618 further mates with and is movably coupled to the cone mandrel 588. An end of an emergency release sleeve 622 that defines radial passages 622a, an outer annular recess 622b, and a longitudinal passage 622c is received within and is threadably coupled to an end of the lower mandrel 610. The emergency release sleeve 622 is also received within, mates with, and slidably and sealingly engages an end of the cone mandrel 588.

[0154] An end of a pressure balance piston 624 is received within, mates with, and slidably and sealingly engages the end of the lower mandrel 610 and receives, mates with, and is threadably coupled to an end of the cone mandrel 588. The other end of the pressure balance piston 624 receives, mates with, and slidably and sealingly engages the emergency release sleeve 622.

[0155] An end of a bypass valve operating probe 626 that defines a longitudinal passage 626a is received within and is threadably coupled to another end of the lower mandrel 610. An end of an expansion cone mandrel 628 that defines radial passages 628a receives and is threadably coupled to the other end of the lower mandrel 610. A sealing sleeve expansion cone 630 is slidably coupled to the other end of the expansion cone mandrel 628 that includes an outer tapered expansion surface 630a. A guide 632 is releasably coupled to another end of the expansion cone mandrel 628 by a retaining collet 634.

[0156] An end of an expandable sealing sleeve 636 receives and is mounted on the sealing sleeve expansion cone 630 and the guide 632. The other end of the expandable sealing sleeve 636 receives and is threadably coupled to an end of a bypass valve body 638 that defines radial passages, 638a and 638b. An elastomeric coating 640 is coupled to the exterior of at least a portion of the expandable sealing sleeve 636. An end of a probe guide 642 that defines an inner annular recess 642a is received within and is threadably coupled to an end of the bypass valve body 638 and receives and mates with an end of the bypass valve operating probe 626.

[0157] A bypass valve 644 that defines a longitudinal passage 644a and radial passages, 644b and 644c, and includes a collet locking member 644d at one end for releasably engaging an end of the bypass valve operating probe 626 is received within, mates with, and slidably and sealingly engages the bypass valve body 638. An end of a lower mandrel 646 that defines a longitudinal passage 646a receives and is threadably coupled to an end of the bypass valve body 638.

[0158] An end of a dart guide sleeve 648 that defines a longitudinal passage 648a is received within and is coupled to an end of the bypass valve body 638 and the other end of the dart guide sleeve 648 is received within and is coupled with the lower mandrel 646. An end of a differential piston 650 that includes an inner flange 650a at another end receives and is coupled to an end of the lower mandrel 646 by one or more shear pins 652. An end of a float valve assembly 654 including a float valve 654a, a valve guard 654b, and a guide nose 654c receives and is threadably coupled to an end of the lower mandrel 646. A plurality of circumferentially spaced apart locking dogs 656 are pivotally coupled to the inner flange 650a of the differential piston 650 and are further supported by an end of the float valve assembly 654.

[0159] As illustrated in Figs. 24a-24k, in an exemplary embodiment, during operation of the apparatus 400, the apparatus is initially positioned within a preexisting structure 700 such as, for example, a wellbore that traverses a subterranean formation. In several alternative embodiments, the wellbore 700 may have any inclination from vertical to horizontal. Furthermore, in several alternative embodiments, the wellbore 700 may also include one or more preexisting wellbore casings, or other well construction elements, coupled to the wellbore. During the positioning of the apparatus 400 within the wellbore 700, the casings, 468 and 470, are supported by the positive casing locking dog 464 and the torsional shear pins, 592a and 592b. In this manner, axial and torque loads may be transmitted between the casings, 468 and 470, and the tubular support member 402.

[0160] In an exemplary embodiment, as illustrated in Fig. 25h, prior to the assembly of the apparatus 400, the force of the spring 418 applies a sufficient downward longitudinal force to position the ends of the casing gripper locking dogs, 424a and 424b, between the outer annular recesses, 406d and 406e, of the gripper upper mandrel 406 thereby placing the bypass valve body 412 in a neutral position. In an exemplary embodiment, when the apparatus 400 is assembled by inserting the apparatus into the casing 468, the ends of the casing gripper locking dogs, 424a and 424b, impact the upper end of the casing 468 and are thereby displaced, along with the bypass valve body 412, upwardly relative to the gripper upper mandrel 406 until the ends of the casing gripper locking dogs pivot radially inwardly into engagement with the outer annular recess 406d of the gripper upper mandrel. In this manner, the bypass valve body 412 is positioned in an inactive position, as illustrated in Fig. 24a, that fluidicly decouples the casing gripper hydraulic ports, 406f and 406h. The upward displacement of the bypass valve body 412 relative to the gripper upper mandrel 406 further compresses the spring 418. The bypass valve body 412 is then maintained in the inactive position due to the placement of the casing gripper locking dogs, 424a and 424b, within the casing 468 thereby preventing the ends of the casing gripper locking dogs from pivoting radially outward out of engagement with the outer annular recess 406d.

[0161] Referring to Figs. 26a-26k, when the apparatus 400 is positioned at a desired predetermined position within the wellbore 700, a fluidic material 702 is injected into the apparatus through the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 484a, 522a, 529a, 534a, 544a, 554a,

566a, 588a, 622c, 610a, 626a, 644a, and 646a and out of the apparatus through the float valve 654a. In this manner the proper operation of the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 484a, 522a, 529a, 534a, 544a, 554a, 566a, 588a, 622c, 610a, 626a, 644a, and 646a and the float valve 654a may be tested. A dart 704 is then injected into the apparatus with the fluidic material 702 through the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 484a, 522a, 529a, 534a, 544a, 554a, 566a, 588a, 622c, 610a, 626a, and 644a until the dart is positioned and seated in the passage 646a of the lower mandrel 646. As a result of the positioning of the dart 704 in the passage 646a of the lower mandrel 646, the passage of the lower mandrel is thereby closed.

[0162] The fluidic material 702 is then injected into the apparatus thereby increasing the operating pressure within the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 484a, 522a, 529a, 534a, 544a, 554a, 566a, 588a, 622c, 610a, 626a, and 644a. Furthermore, the continued injection of the fluidic material 702 into the apparatus 400 also causes the fluidic material 702 to pass through the radial passages, 526b and 526c, 530b and 530c, and 536b and 536c, of the piston 526, 530, and 536, respectively, into an annular pressure chamber 706 defined between the actuator barrel 492 and the connector tube 529, an annular pressure chamber 708 defined between the actuator barrel 502 and the connector tube 534, and an annular pressure chamber 710 defined between the actuator barrel 512 and the connector tube 544.

[0163] The pressurization of the annular pressure chambers, 706, 708, and 710 then cause the pistons 526, 530, and 536 to be displaced upwardly relative to the casing 470. As a result, the connector tube 529, the connector tube 534, the connector tube 544, the threaded bushing 550, the lock nut 552, the tool joint adaptor 554, the sealing sleeve 558, the tool joint adaptor 560, the torsion plate 562, the upper bushing 564, the cup mandrel 566, the thimble 568, the inner thimble 570, the packer cup 572, the backup ring 574, the spacer 576, the thimble 578, the inner thimble 580, the packer cup 582, the backup ring 584, the spacer 586, and the cone mandrel 588 are displaced upwardly relative to the casing 470, the shear pin bushing 590, the locking ring 594, the upper cone retainer 596, the upper cam 598, and the upper cone segments 600.

[0164] As a result, as illustrated in Figs. 26j, 27a, and 27b, the shear pin bushing 590, the locking ring 594, the upper cone retainer 596, the upper cam 598, and the upper cone segments 600 are displaced downwardly relative to the cone mandrel 588, the lower cone segments 602, and the lower cam 604 thereby driving the upper cone segments 600 onto and up the cam arms 604a of the lower cam 604, and driving the lower cone segments 602 onto and up the cam arms 598d of the upper cam 598. During the outward radial displacement of the upper and lower cone segments, 600 and 602, the upper and cone segments translate towards one another in the longitudinal direction and also pivot about the pivot points, 596b and 606a, of the upper and lower cone retainers, 596 and 606, respectively.

[0165] As a result, a segmented expansion cone is formed that includes a substantially continuous outer arcuate spherical surface provided by the axially aligned and interleaved upper and lower expansion cone segments, 600 and 602. Furthermore, the resilient locking ring 594 is relocated from

the lock ring groove 588b to the lock ring groove 588c thereby releasably locking the positions of the shear pin bushing 590, the locking ring 594, the upper cone retainer 596, the upper cam 598, and the upper cone segments 600 relative to the cone mandrel 588.

[0166] Referring to Figs. 28a to 28j, the continued injection of the fluidic material 702 into the apparatus 400 continues to pressurize annular pressure chambers, 706, 708, and 710. As a result, an upward axial force is applied to the shear pin bushing 590 that causes the torsional shear pins, 592a and 592b, to be sheared thereby decoupling the wellbore casing 470 from the shear pin bushing 590 and permitting the pistons 526, 530, and 536 to be further displaced upwardly relative to the casing 470. The further upward displacement of the pistons 526, 530, and 536 in turn displaces the cone mandrel 588, the upper cam 598, the upper cone segments 600, the lower cone segments 602, and the lower cam 604 upwardly relative to the casing 470. As a result, the segmented expansion cone provided by the interleaved and axially aligned upper and lower cone segments, 600 and 602, radially expands and plastically deforms a portion of the casing 470.

[0167] Referring to Figs. 29a-29m, during the continued injection of the fluidic material 702, the segmented expansion cone provided by the interleaved and axially aligned upper and lower cone segments, 600 and 602, will continue to be displaced upwardly relative to the casing 470 thereby continuing to radially expand and plastically deform the casing until the locking dogs 656 engage and push on the lower end of the casing 470. When the locking dogs 656 engage and push on the lower end of the casing 470, the locking dogs 656, the float valve assembly 654, the differential piston 650, the dart guide sleeve 648, the lower mandrel 646, the bypass valve 644, the elastomeric coating 640, the bypass valve body 638, the expandable sealing sleeve 636, the retaining collet 634, the guide 632, the sealing sleeve expansion cone 630, the expansion cone mandrel 628, the bypass valve operating probe 626, the pressure balance piston 624, the emergency release sleeve 622, the resilient locking ring 620, the locking ring retainer 618, the locking dogs 616, the locking dog retainer sleeve 614, the torsion locking pin 612, the lower mandrel 610, the release housing 608, the lower cone retainer 606, the lower cam 604, and the lower cone segments 602 are displaced downwardly in the longitudinal direction relative to the cone mandrel 588. As a result, the upper cam 598 and the upper cone segments 600 are moved out of axial alignment with the lower cone segments 602 and the lower cam 604 thereby collapsing the segmented expansion cone. Furthermore, the locking ring 620 is moved from the lock ring groove 588d to the lock ring groove 588e thereby releasably fixing the new position of the lower cone segments 602 and the lower cam 604.

[0168] In particular, as illustrated in Fig. 30a, when a downward tensile longitudinal force is initially applied to the lower mandrel 610 relative to cone mandrel 588, the lower mandrel, the locking dog retainer sleeve 614, and the locking ring retainer 618 are displaced downwardly relative to the cone mandrel 588 when the applied tensile force is sufficient to release the locking ring 620 from engagement with the lock ring groove 588d. As illustrated in Fig. 30b, if the applied tensile force is sufficient to release the locking ring 620 from engagement with the lock ring groove 588d, the lower

mandrel 610, the locking dog retainer sleeve 614, and the locking ring retainer 618 are displaced downwardly relative to the cone mandrel 588 thereby displacing the annular recess 614a of the locking dog retainer sleeve downwardly relative to the locking dogs 616. As a result, the locking dogs 616 are released from engagement with the locking dog grooves 588h of the cone mandrel 588 thereby permitting the lower cone segments 602, the lower cam 604, and the lower cone retainer 606 to be displaced downwardly relative to the cone mandrel 588.

[0169] As illustrated in Fig. 30c, further downward displacement of the lower mandrel 610 then causes the torsion locking pin 612 to engage and displace the release housing 608 downwardly relative to the cone mandrel 588 thereby displacing the locking dogs 616, the lower cone retainer 606, the lower cam 604, and the lower cam segments 602 downwardly relative to the cone mandrel. As a result, the lower cone segments 602 and the lower cam 604 are displaced downwardly out of axial alignment with the upper cam 598 and the upper cam segments 600 thereby collapsing the segmented expansion cone. Furthermore, the downward displacement of the locking dog retainer sleeve 614 also displaced the locking ring retainer 618 and the locking ring 620 downwardly relative to the cone mandrel 588 thereby relocating the locking ring from the lock ring groove 588d to the lock ring groove 588e. In this manner, the now position of the lower cone segments 602 and the lower cam 604 are thereby releasably fixed relative to the cam mandrel 588 by the locking ring 620.

[0170] The operations of Figs. 30a-30c may be reversed, and the segmented expansion cone may again be expanded, by applying a upward compressive force to the lower mandrel 610. If the compressive force is sufficient, the locking ring 620 will be released from engagement with the lock ring groove 588e, thereby permitting the lower mandrel 610 and the locking dog retainer 614 to be displaced upwardly relative to the cone mandrel 588. As a result, the locking dog retainer 614 will engage and displace the locking dogs 616, the lower cam 604, the lower cone segments 602, the lower cone retainer 606, and the release housing 608 upwardly relative to the cone mandrel 588 thereby bringing the upper cam 598 and the upper cone segments 600 back into axial alignment with the lower cone segments 602 and the lower cam 604. As a result, the segmented expansion cone is once again expanded. Once the segmented cone has been fully expanded, the locking dogs 616 will once again be positioned in alignment with the locking dog grooves 588h of the cone mandrel 588 and will thereby once again engage the locking dog grooves. The continued upward displacement of the lower mandrel 610 relative to cone mandrel 588 will thereby also upwardly displace the locking dog retainer 614 upwardly relative to the cone mandrel thereby once again capturing and restraining the locking dogs 616 within the annular recess 614a of the locking dog retainer. As a result, the new expansion position of the lower cone segments 602 and the lower cam 604 relative to the cone mandrel 588 will be releasably locked by the locking dogs 616. Furthermore, the locking ring 620 will also be relocated from engagement with the lock ring groove 588e to engagement with the lock ring groove 588d to thereby releasably lock the expanded segmented cone in the expanded position.

[0171] Referring to Figs. 31a-31n, the continued injection of the fluidic material 702 into the apparatus 400 continues to pressurize the piston chambers 706, 708, and 710 thereby further displacing the pistons upwardly 526, 530, and 536 upwardly relative to the support member 402. Because the engagement of the locking dogs 656 with the lower end of the casing 470 prevents float valve 654 from entering the casing, the continued upward displacement of the pistons 526, 530, and 536 relative to the support member 402 causes the bypass valve operating probe 626 to be displaced upwardly relative to the support member thereby disengaging the bypass valve operating probe from the probe guide 642, and also causes the sealing sleeve expansion cone 630 to be displaced upwardly relative to the expandable sealing sleeve 636 thereby radially expanding and plastically deforming the sealing sleeve 636 and the elastomeric coating 640 into sealing engagement with the interior surface of the lower end of the casing 470. As a result, the lower end of the casing 470 is fluidicly sealed by the combination of the sealing engagement of the sealing sleeve 636 and elastomeric coating 640 with the interior surface of the lower end of the casing and the positioning the dart 704 within the passage 646a of the lower mandrel 646.

[0172] Continued injection of the fluidic material 702 into the apparatus 400 continues to pressurize the piston chambers 706, 708, and 710 until the pistons 536, 530 and 536 are displaced upwardly relative to the casing 470 to their maximum upward position relative to the support member 402. As a result, the dart ball guide 524 impacts the positive casing lock mandrel 478 with sufficient force to shear the shear pins, 428a and 428b, thereby decoupling the positive casing lock mandrel 478 from the casing lock barrel adaptor 474. The positive casing lock mandrel 478 is then displaced upwardly relative to the support member 402 which in turn displaces the positive casing lock releasing mandrel 476 upwardly relative to the positive casing locking dogs 464. As a result, the internal flanges, 464a and 464b, of the positive casing locking dogs are relocated into engagement with the annular recesses, 476c and 476d, respectively, of the positive casing lock releasing mandrel 476. The positive casing lock casing collar 466 is thereby released from engagement with the positive casing locking dogs 464 thereby releasing the casings 468 and 470 from engagement with the support member 402. As a result, the positions of the casings, 468 and 470, are no longer fixed relative to the support member 402.

[0173] Referring to Figs. 32a-32k, the injection of the fluidic material 702 is stopped and the support member 402 is then lowered into the wellbore 700 until the float valve assembly 654 impacts the bottom of the wellbore. The support member 402 is then further lowered into the wellbore 700, with the float valve assembly 654 resting on the bottom of the wellbore, until the bypass valve operating probe 626 impacts and displaces the bypass valve 644 downwardly relative to the bypass valve body 638 to fluidicly couple the passages, 638a and 644b, and the passages, 638b and 644c, and until sufficient upward compressive force has been applied to the lower mandrel 610 to re-expand the segmented expansion cone provided by the cone segments, 600 and 602. In an exemplary embodiment, the collet locking member 644d of the bypass valve 644 will also engage an end of the bypass valve operating probe 626.

[0174] In an exemplary embodiment, the support member 402 is lowered downwardly into the wellbore 700 such that sufficient upward compressive force is applied to the lower mandrel 610 to release the locking ring 620 from engagement with the lock ring groove 588e, thereby permitting the lower mandrel 610 and the locking dog retainer 614 to be displaced upwardly relative to the cone mandrel 588. As a result, the locking dog retainer 614 will engage and displace the locking dogs 616, the lower cam 604, the lower cone segments 602, the lower cone retainer 606, and the release housing 608 upwardly relative to the cone mandrel 588 thereby bringing the upper cam 598 and the upper cone segments 600 back into axial alignment with the lower cone segments 602 and the lower cam 604. As a result, the segmented expansion cone is once again expanded. Once the segmented cone has been fully expanded, the locking dogs 616 will once again be positioned in alignment with the locking dog grooves 588h of the cone mandrel 588 and will thereby once again engage the locking dog grooves. The continued upward displacement of the lower mandrel 610 relative to cone mandrel 588 will thereby also upwardly displace the locking dog retainer 614 upwardly relative to the cone mandrel thereby once again capturing and restraining the locking dogs 616 within the annular recess 614a of the locking dog retainer. As a result, the new expansion position of the lower cone segments 602 and the lower cam 604 relative to the cone mandrel 588 will be releasably locked by the locking dogs 616. Furthermore, the locking ring 620 will also be relocated from engagement with the lock ring groove 588e to engagement with the lock ring groove 588d to thereby releasably lock the expanded segmented cone in the expanded position.

[0175] A hardenable fluidic sealing material 712 may then be injected into the apparatus 400 through the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 522a, 526a, 529a, 530a, 534a, 536a, 544a, 554a, 566a, 588a, 622a, 610a, 626a, 638a, 638b, 644b, and 644c, and out of the apparatus through the circumferential gaps defined between the circumferentially spaced apart locking dogs 656 into the annulus between the casings 468 and 470 and the wellbore 700. In an exemplary embodiment, the hardenable fluidic sealing material 712 is a cement suitable for well construction. The hardenable fluidic sealing material 712 may then be allowed to cure before or after the further radial expansion and plastic deformation of the casings 468 and/or 470.

[0176] Referring to Figs. 33a-33p, after completing the injection of the fluidic material 712, the support member 402 is then lifted upwardly thereby displacing the bypass valve operating probe 626 and the bypass valve 644 upwardly to fluidicly decouple the passages, 638a and 644b and 638b and 644c, until the collet locking member 644d of the bypass valve is decoupled from the bypass valve operating probe. The support member 402 is then further lifted upwardly until the segmented expansion cone, provided by the interleaved and axially aligned cone segments, 600 and 602, impacts the transition between the expanded and unexpanded sections of the casing 470. A fluidic material 714 is then injected into the apparatus 400 through the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 478a, 484a, 524a, 522a, 526a, 529a, 530a, 534a, 536a, 544a, 554a, 566a, 588a, 622c, 610a, and 626a thereby pressurizing the interior portion of the casing 470 below the packer cups, 572 and 582. In

particular, the packer cups, 572 and 582, engage the interior surface of the casings 468 and/or 470 and thereby provide a dynamic movable fluidic seal. As a result, the pressure differential across the packer cups, 572 and 582, causes an upward tensile force that pulls the segmented expansion cone provided by the axially aligned and interleaved cone segments, 600 and 602, to be pulled upwardly out of the casings 468 and/or 407 by the packer cups thereby radially expanding and plastically deforming the casings. Furthermore, the lack of a fluid tight seal between the cone segments, 572 and 582, and the casings 468 and/or 470 permits the fluidic material 714 to lubricate the interface between the cone segments and the casings during the radial expansion and plastic deformations of the casings by the cone segments. In an exemplary embodiment, during the radial expansion and plastic deformation of the wellbore casings 468 and/or 470, the support member 402 is lifted upwardly out of the wellbore 700. In several alternative embodiments, the casings 468 and/or 470 are radially expanded and plastically deformed into engagement with at least a portion of the interior surface of the wellbore 700.

[0177] Referring to Figs. 34a-34l, in an exemplary embodiment, a preexisting wellbore casing 716 is coupled to, or otherwise support by or within, the wellbore 700. In an exemplary embodiment, during the radial expansion and plastic deformation of the portion of the casing 468 and/or 470 that overlaps with the preexisting casing 716, during the continued injection of the fluidic material 714, the bypass valve body 412 is shifted downwardly relative to the gripper upper mandrel 406 thereby fluidicly coupling the casing gripper hydraulic ports, 406f and 406h. As a result, the interior passages, 428a and 440a, of the gripper bodies, 428 and 440, are pressurized thereby displacing the hydraulic slip pistons, 432a-432j and 442a-442j, radially outward into engagement with the interior surface of the preexisting wellbore casing 716. After the hydraulic slip pistons, 432a-432j and 442a-442j, engage the preexisting wellbore casing 716, the continued injection of the fluidic material 714 causes the segmented expansion cone including the axially aligned and interleaved cone segments, 600 and 602, to be pulled through the overlapping portions of the casings 468 and/or 470 and the preexisting wellbore casing by the upward displacement of the pistons, 526, 530, and 536, relative to the preexisting wellbore casing. In this manner, the overlapping portions of the casings 468 and/or 470 and the preexisting wellbore casing 716 are simultaneously radially expanded and plastically deformed by the upward displacement of the segmented expansion cone including the axially aligned and interleaved cone segments, 600 and 602. In several alternative embodiments, the hydraulic slip pistons, 432a-432j and 442a-442j, are displaced radially outward into engagement with the interior surface of the casings 468 and/or 470 and/or the preexisting wellbore casing 716.

[0178] In an exemplary embodiment, the bypass valve body 412 is shifted downwardly relative to the gripper upper mandrel 406 by lowering the casing gripper locking dogs, 424a and 424b, using the support member 402 to a position below the unexpanded portions of the casings 468 and/or 470 into the radially expanded and plastically deformed portions of the casings. The ends of the casing gripper locking dogs, 424a and 424b, may then pivot outwardly out of engagement with the outer annular recess 406d of the gripper upper mandrel 406 and then are displaced downwardly relative to the gripper

upper mandrel, along with the bypass valve body 412, due to the downward longitudinal force provided by the compressed spring 418. As a result, the bypass valve body 412 is placed in the neutral position illustrated in Fig. 25h. The casing gripper locking dogs, 424a and 424b, are then displaced upwardly relative to the casing gripper upper mandrel 406 using the support member 402 thereby impacting the casing gripper locking dogs with the interior diameter of the unexpanded portion of the casings 468 and/or 470. As a result, the casing gripper locking dogs, 424a and 424b, are displaced downwardly, along with the bypass valve body 412. relative to the casing gripper upper mandrel 406 until the ends of the casing gripper locking dogs pivot radially inwardly into engagement with the outer annular recess 406e of the casing gripper upper mandrel thereby positioning the bypass valve body in an active position, as illustrated in Fig. 34a, in which the casing gripper hydraulic ports, 406f and 406h, are fluidicly coupled.

[0179] In an alternative embodiment, the bypass valve body 412 is shifted downwardly relative to the gripper upper mandrel 406 by raising the casing gripper locking dogs, 424a and 424b, to a position above the casing 468 using the support member 402 thereby permitting the ends of the casing gripper locking dogs to pivot radially outward out of engagement with the outer annular recess 406d of the gripper upper mandrel 406. The ends of the casing gripper locking dogs, 424a and 424b, are then displaced downwardly relative to the gripper upper mandrel, along with the bypass valve body 412, due to the downward longitudinal force provided by the compressed spring 418, into engagement with the outer annular recess 406e of the casing gripper upper mandrel thereby positioning the bypass valve body in an active position, as illustrated in Fig. 34a, in which the casing gripper hydraulic ports, 406f and 406h, are fluidicly coupled.

[0180] In an exemplary embodiment, the process of pulling the segmented expansion cone provided by pulling the interleaved and axially aligned cone segments, 600 and 602, upwardly through the overlapping portions of the casings 468 and/or 470 and the preexisting wellbore casing 716 is repeated by repeatedly stroking the pistons, 526, 530, and 536, upwardly by repeatedly a) injecting the fluidic material 714 to pressurize the apparatus 400 thereby displacing the segmented expansion cone upwardly, b) depressurizing the apparatus by halting the injection of the fluidic material, and then c) lifting the elements of the apparatus upwardly using the support member 402 in order to properly position the pistons for another upward stroke.

[0181] Referring to Figs. 35a-35l, in an exemplary embodiment, during the operation of the apparatus 400, the segmented expansion cone provided by the interleaved and axially aligned cone segments, 600 and 602, may be collapsed thereby moving the cone segments out of axial alignment by injecting a ball plug 718 into the apparatus using the injected fluidic material 714 through the passages 402a, 404a, 406a, 454a, 450a, 456a, 458a, 476a, 484a, 522a, 529a, 534a, 544a, 554a, 566a, and 588a into sealing engagement with the end of the emergency releasing sleeve 622. The continued injection of the fluidic material 714 following the sealing engagement of the ball plug 718 with the end of the emergency releasing sleeve 622 will apply a downward longitudinal tensile force to the lower mandrel

610. As a result, as illustrated and described above with reference to Fig. 30a, when the downward tensile longitudinal force is initially applied to the lower mandrel 610 relative to cone mandrel 588, the lower mandrel, the locking dog retainer sleeve 614, and the locking ring retainer 618 are displaced downwardly relative to the cone mandrel 588 when the applied tensile force is sufficient to release the locking ring 620 from engagement with the lock ring groove 588d. As illustrated in Fig. 30b, if the applied downward tensile longitudinal force is sufficient to release the locking ring 620 from engagement with the lock ring groove 588d, the lower mandrel 610, the locking dog retainer sleeve 614, and the locking ring retainer 618 are displaced downwardly relative to the cone mandrel 588 thereby displacing the annular recess 614a of the locking dog retainer sleeve downwardly relative to the locking dogs 616. As a result, the locking dogs 616 are released from engagement with the locking dog grooves 588h of the cone mandrel 588 thereby permitting the lower cone segments 602, the lower cam 604, and the lower cone retainer 606 to be displaced downwardly relative to the cone mandrel 588.

[0182] As illustrated in Fig. 30c, further downward displacement of the lower mandrel 610 then causes the torsion locking pin 612 to engage and displace the release housing 608 downwardly relative to the cone mandrel 588 thereby displacing the locking dogs 616, the lower cone retainer 606, the lower cam 604, and the lower cam segments 602 downwardly relative to the cone mandrel. As a result, the lower cone segments 602 and the lower cam 604 are displaced downwardly out of axial alignment with the upper cam 598 and the upper cam segments 600 thereby collapsing the segmented expansion cone. Furthermore, the downward displacement of the locking dog retainer sleeve 614 also displaced the locking ring retainer 618 and the locking ring 620 downwardly relative to the cone mandrel 588 thereby relocating the locking ring from the lock ring groove 588d to the lock ring groove 588e. In this manner, the now position of the lower cone segments 602 and the lower cam 604 are thereby releasably fixed relative to the cam mandrel 588 by the locking ring 620.

[0183] Referring now to Fig. 36a, an exemplary embodiment of the operation of the pressure balance piston 624 during an exemplary embodiment of the operation of the apparatus 400 will now be described. In particular, after the dart 704 is positioned and seated in the passage 646a of the lower mandrel 646, the operating pressure within the passage 622c will increase. As a result, the operating pressure within the passages 622a will increase thereby increasing the operating pressures within the passages, 588f and 588g, of the cone mandrel 588, and within an annulus 720 defined between the cone mandrel 588 and lower mandrel 610. The operating pressure within the annulus 720 acts upon an end face of the pressure balance piston 624 thereby applying a downward longitudinal force to the cone mandrel 588. As a result, the cone mandrel 588 and the locking dog retainer sleeve 614 could inadvertently be displaced away from each other in opposite directions during the pressurization of the interior passages of the apparatus 400 caused by the placement of the dart 704 in the passage 646a of the lower mandrel 646 thereby potentially collapsing the segmented expansion cone including the interleaved and axially aligned cone segments, 600 and 602. Thus, the pressure balance piston 624, in an exemplary embodiment, neutralizes the potential effects of the pressurization of the interior passages

of the apparatus 400 caused by the placement of the dart 704 in the passage 646a of the lower mandrel 646.

[0184] Referring now to Fig. 36b, an exemplary embodiment of the operation of the pressure balance piston 624 during another exemplary embodiment of the operation of the apparatus 400 will now be described. In particular, during the placement of the ball 718 within the passage 622c of the releasing sleeve 622, the interior passages of the apparatus 400 upstream from the ball are pressurized. However, since the ball 718 blocks the passage 622c, the passage 622a is not pressurized. As a result, the pressure balance piston 624 does not apply a downward longitudinal force to the cone mandrel 588. As a result, the pressure balance piston 624 does not interfere with the collapse of the segmented expansion cone including the interleaved and axially aligned cone segments, 600 and 602, caused by the placement of the ball 718 within the mouth of the passage 622c of the release sleeve 622.

[0185] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

[0186] A method for radially expanding and plastically deforming an expandable tubular member within a borehole has been described that includes positioning an adjustable expansion mandrel within the expandable tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

[0187] A method for forming a mono diameter wellbore casing has been described that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

[0188] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during radial expansion of the expandable tubular member.

[0189] A method for radially expanding and plastically deforming an expandable tubular member within a borehole has been described that includes positioning an adjustable expansion mandrel within the expandable tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole, and pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

[0190] A method for forming a mono diameter wellbore casing has been described that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole, pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second

expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole, and pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

[0191] An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

[0192] A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole has been described that includes positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole.

[0193] A method for forming a mono diameter wellbore casing within a borehole has been described that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member

within the second drilled section of the borehole, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole.

[0194] An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealing engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during the radial expansion of the expandable tubular member.

[0195] A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole has been described that includes positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole, and pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

[0196] A method for forming a mono diameter wellbore casing within a borehole has been described that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the

first expandable tubular member within the drilled first section of the borehole, pressuring an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole, and pressuring an interior portion of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the drilled second section of the borehole.

[0197] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension, a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension, an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device. The first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

[0198] A method for radially expanding and plastically deforming an expandable tubular member within a borehole has been described that includes positioning first and second adjustable expansion mandrels within the expandable tubular member, supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole, lowering the first adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member, decreasing the

outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, and displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0199] A method for forming a mono diameter wellbore casing has been described that includes positioning first and second adjustable expansion mandrels within a first expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole, lowering the first adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member, positioning first and second adjustable expansion mandrels within a second expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member, lowering the first adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, and displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0200] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a float shoe adapted to mate with an end of the expandable tubular member, a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular

member or collapsed to a first smaller outside dimension, a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension, an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealingly engaging the expandable tubular adapted to define a pressure chamber above the first and second adjustable expansion mandrels during the radial expansion of the expandable tubular member. The first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

[0201] A method for radially expanding and plastically deforming an expandable tubular member within a borehole has been described that includes positioning first and second adjustable expansion mandrels within the expandable tubular member, supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole, lowering the first adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member, pressurizing an interior region of the expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member, and pressurizing an interior region of the expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the expandable tubular member above the lower portion of the expandable tubular member by the second adjustable expansion mandrel. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0202] A method for forming a mono diameter wellbore casing has been described that includes positioning first and second adjustable expansion mandrels within a first expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole, lowering the first adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially

expand and plastically deform a lower portion of the first expandable tubular member, pressurizing an interior region of the first expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the first expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member, pressurizing an interior region of the first expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the first expandable tubular member above the lower portion of the first expandable tubular member by the second adjustable expansion mandrel, positioning first and second adjustable expansion mandrels within a second expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member, lowering the first adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member, pressurizing an interior region of the second expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the second expandable tubular member by the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member, and pressurizing an interior region of the second expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the second expandable tubular member above the lower portion of the second expandable tubular member by the second adjustable expansion mandrel. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

[0203] An apparatus for radially expanding and plastically deforming an expandable tubular member has been described that includes a support member, a locking device coupled to the support member and releasably coupled to the expandable tubular member, an adjustable expansion mandrel adapted to be controllably expanded to a larger outside dimension for radial expansion and plastic deformation of the expandable tubular member or collapsed to a smaller outside dimension, and an

actuator coupled to the locking member and the adjustable expansion mandrel adapted to displace the adjustable expansion mandrel upwardly through the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the apparatus further includes a gripping assembly coupled to the support member and the actuator for controllably gripping at least one of the expandable tubular member or another tubular member. In an exemplary embodiment, the apparatus further includes one or more cup seals coupled to the support member for sealingly engaging the expandable tubular member above the adjustable expansion mandrel. In an exemplary embodiment, the apparatus further includes an expansion mandrel coupled to the adjustable expansion mandrel, and a float collar assembly coupled to the adjustable expansion mandrel that includes a float valve assembly and a sealing sleeve coupled to the float valve assembly adapted to be radially expanded and plastically deformed by the expansion mandrel.

[0204] A method for radially expanding and plastically deforming an expandable tubular member within a borehole has also been described that includes supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole, increasing the size of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member. In an exemplary embodiment, the method further includes reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed. In an exemplary embodiment, the method further includes fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel. In an exemplary embodiment, the method further includes permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member. In an exemplary embodiment, the method further includes injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator. In an exemplary embodiment, the method further includes increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator. In an exemplary embodiment, the method further includes displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member. In an exemplary embodiment, the method further includes if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator, and displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically

deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

[0205] A method for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing has been described that includes supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole, increasing the size of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member. In an exemplary embodiment, the method further includes reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed. In an exemplary embodiment, the method further includes fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel. In an exemplary embodiment, the method further includes permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member. In an exemplary embodiment, the method further includes injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator. In an exemplary embodiment, the method further includes increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator. In an exemplary embodiment, the method further includes displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member. In an exemplary embodiment, the method further includes not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator, and displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

[0206] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments. In addition, the expansion surfaces of the upper and lower cone

segments, 600 and 602, may include any form of inclined surface or combination of inclined surfaces such as, for example, conical, spherical, elliptical, and/or parabolic that may or may not be faceted. Finally, one or more of the steps of the methods of operation of the exemplary embodiments may be omitted and/or performed in another order.

[0207] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

What is claimed is:

1. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device.

2. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

3. A method for forming a mono diameter wellbore casing, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

4. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;

a support member coupled to the locking device; and

a sealing member for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during radial expansion of the expandable tubular member.

5. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole; and

pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

6. A method for forming a mono diameter wellbore casing, comprising:
positioning an adjustable expansion mandrel within a first expandable tubular member;
supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;
lowering the adjustable expansion mandrel out of the first expandable tubular member;
increasing the outside dimension of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;
pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole;
positioning the adjustable expansion mandrel within a second expandable tubular member;
supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;
lowering the adjustable expansion mandrel out of the second expandable tubular member;
increasing the outside dimension of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole; and
pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

7. An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:
a float shoe adapted to mate with an end of the expandable tubular member;
a drilling member coupled to the float shoe adapted to drill the borehole;
an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;
an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device.

8. A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

coupling a drilling member to an end of the expandable tubular member;

drilling the borehole using the drilling member;

positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole.

9. A method for forming a mono diameter wellbore casing within a borehole, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

coupling a drilling member to an end of the first expandable tubular member;

drilling a first section of the borehole using the drilling member;

supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

coupling the drilling member to an end of the second expandable tubular member;

drilling a second section of the borehole using the drilling member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole.

10. An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

a drilling member coupled to the float shoe adapted to drill the borehole;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;

a support member coupled to the locking device; and

a sealing member for sealing engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during the radial expansion of the expandable tubular member.

11. A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

coupling a drilling member to an end of the expandable tubular member;

drilling the borehole using the drilling member;

positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole; and

pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

12. A method for forming a mono diameter wellbore casing within a borehole, comprising:
positioning an adjustable expansion mandrel within a first expandable tubular member;
coupling a drilling member to an end of the first expandable tubular member;
drilling a first section of the borehole using the drilling member;
supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;
lowering the adjustable expansion mandrel out of the first expandable tubular member;
increasing the outside dimension of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;
pressuring an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole;
positioning the adjustable expansion mandrel within a second expandable tubular member;
coupling the drilling member to an end of the second expandable tubular member;
drilling a second section of the borehole using the drilling member;
supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;
lowering the adjustable expansion mandrel out of the second expandable tubular member;
increasing the outside dimension of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole; and
pressuring an interior portion of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the drilled second section of the borehole.

13. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
a float shoe adapted to mate with an end of the expandable tubular member;
a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension;

a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension;

an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device;

wherein the first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

14. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning first and second adjustable expansion mandrels within the expandable tubular member;

supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

lowering the first adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

15. A method for forming a mono diameter wellbore casing, comprising:

positioning first and second adjustable expansion mandrels within a first expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

lowering the first adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member;

positioning first and second adjustable expansion mandrels within a second expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

lowering the first adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel; and

displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

16. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension;

a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension;

an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;

a support member coupled to the locking device; and

a sealing member for sealingly engaging the expandable tubular adapted to define a pressure chamber above the first and second adjustable expansion mandrels during the radial expansion of the expandable tubular member;

wherein the first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

17. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning first and second adjustable expansion mandrels within the expandable tubular member;

supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

lowering the first adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

pressurizing an interior region of the expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member; and

pressurizing an interior region of the expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the expandable tubular member above the lower portion of the expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

18. A method for forming a mono diameter wellbore casing, comprising:

positioning first and second adjustable expansion mandrels within a first expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

lowering the first adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

pressurizing an interior region of the first expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the first expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first

expandable tubular member above the lower portion of the expandable tubular member;

pressurizing an interior region of the first expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the first expandable tubular member above the lower portion of the first expandable tubular member by the second adjustable expansion mandrel;

positioning first and second adjustable expansion mandrels within a second expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

lowering the first adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

pressurizing an interior region of the second expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the second expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member; and

pressurizing an interior region of the second expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the second expandable tubular member above the lower portion of the second expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

19. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

a locking device coupled to the support member and releasably coupled to the expandable tubular member;

an adjustable expansion mandrel adapted to be controllably expanded to a larger outside dimension for radial expansion and plastic deformation of the expandable tubular member or collapsed to a smaller outside dimension; and

an actuator coupled to the locking member and the adjustable expansion mandrel adapted to displace the adjustable expansion mandrel upwardly through the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

20. The apparatus of claim 19, further comprising:

a gripping assembly coupled to the support member and the actuator for controllably gripping at least one of the expandable tubular member or another tubular member.

21. The apparatus of claim 19, further comprising:

one or more cup seals coupled to the support member for sealingly engaging the expandable tubular member above the adjustable expansion mandrel.

22. The apparatus of claim 19, further comprising:

an expansion mandrel coupled to the adjustable expansion mandrel; and

a float collar assembly coupled to the adjustable expansion mandrel comprising:

a float valve assembly; and

a sealing sleeve coupled to the float valve assembly adapted to be radially expanded and plastically deformed by the expansion mandrel.

23. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;

increasing the size of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

24. The method of claim 23, further comprising:

reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed.

25. The method of claim 24, further comprising:
fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

26. The method of claim 25, further comprising:
permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

27. The method of claim 26, further comprising:
injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

28. The method of claim 26, further comprising:
increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

29. The method of claim 28, further comprising:
displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

30. The method of claim 29, further comprising:
if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then
not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

31. A method for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing, comprising:

supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;

increasing the size of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

32. The method of claim 31, further comprising:

reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed.

33. The method of claim 32, further comprising:

fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

34. The method of claim 33, further comprising:

permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

35. The method of claim 34, further comprising:

injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

36. The method of claim 34, further comprising:

increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

37. The method of claim 36, further comprising:

displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member.

38. The method of claim 37, further comprising:

not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and

displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

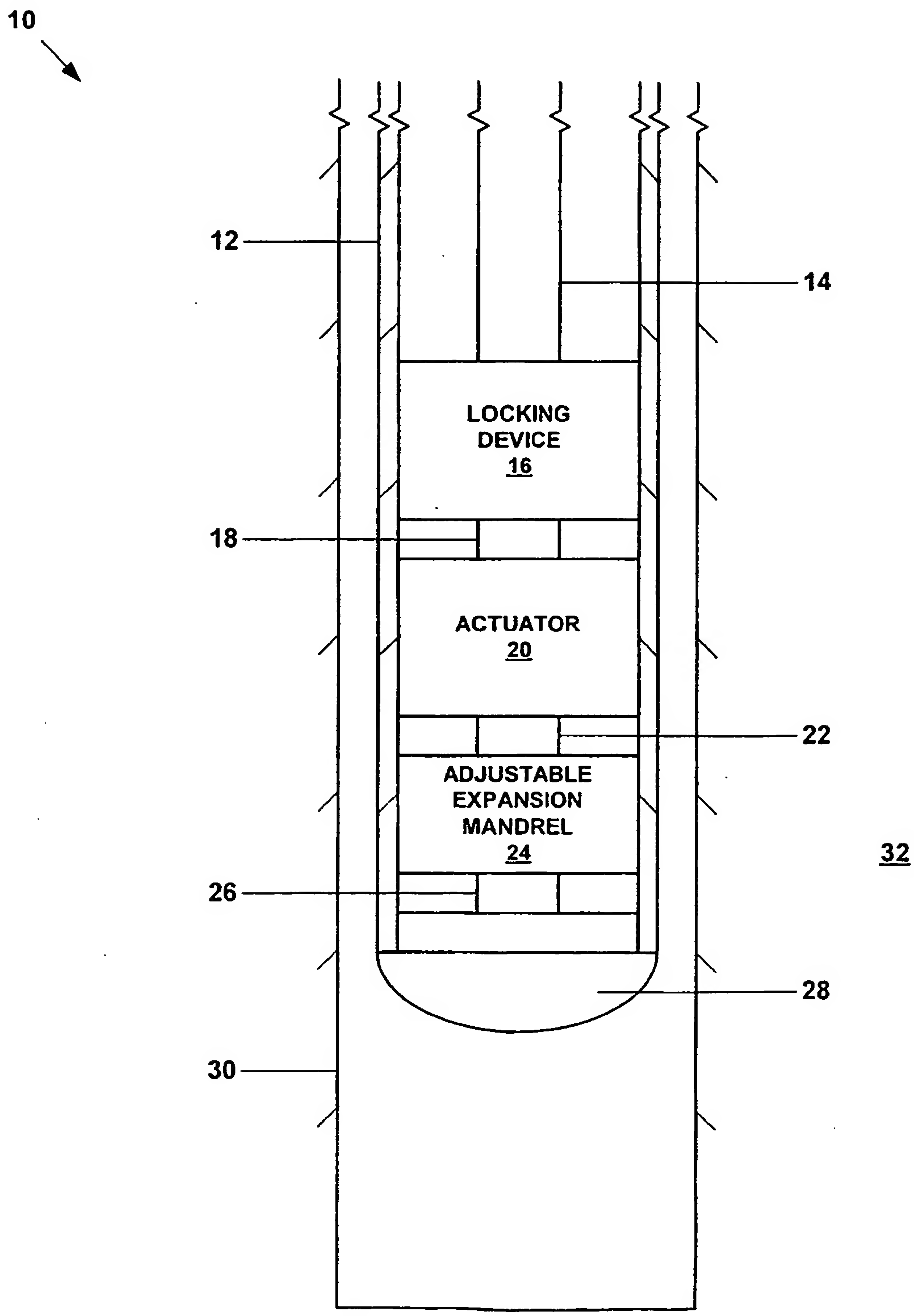
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Fig. 1

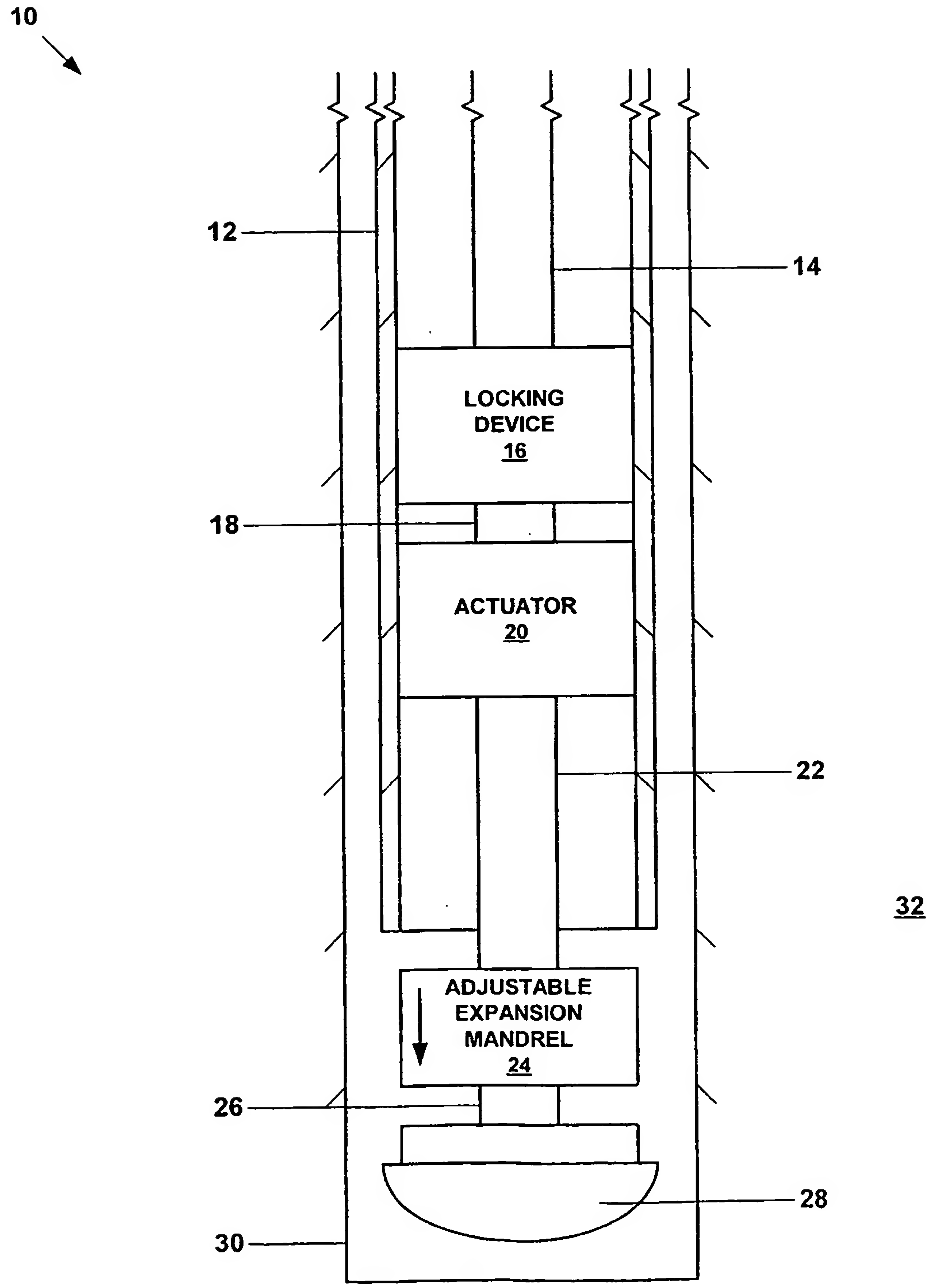
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Fig. 2

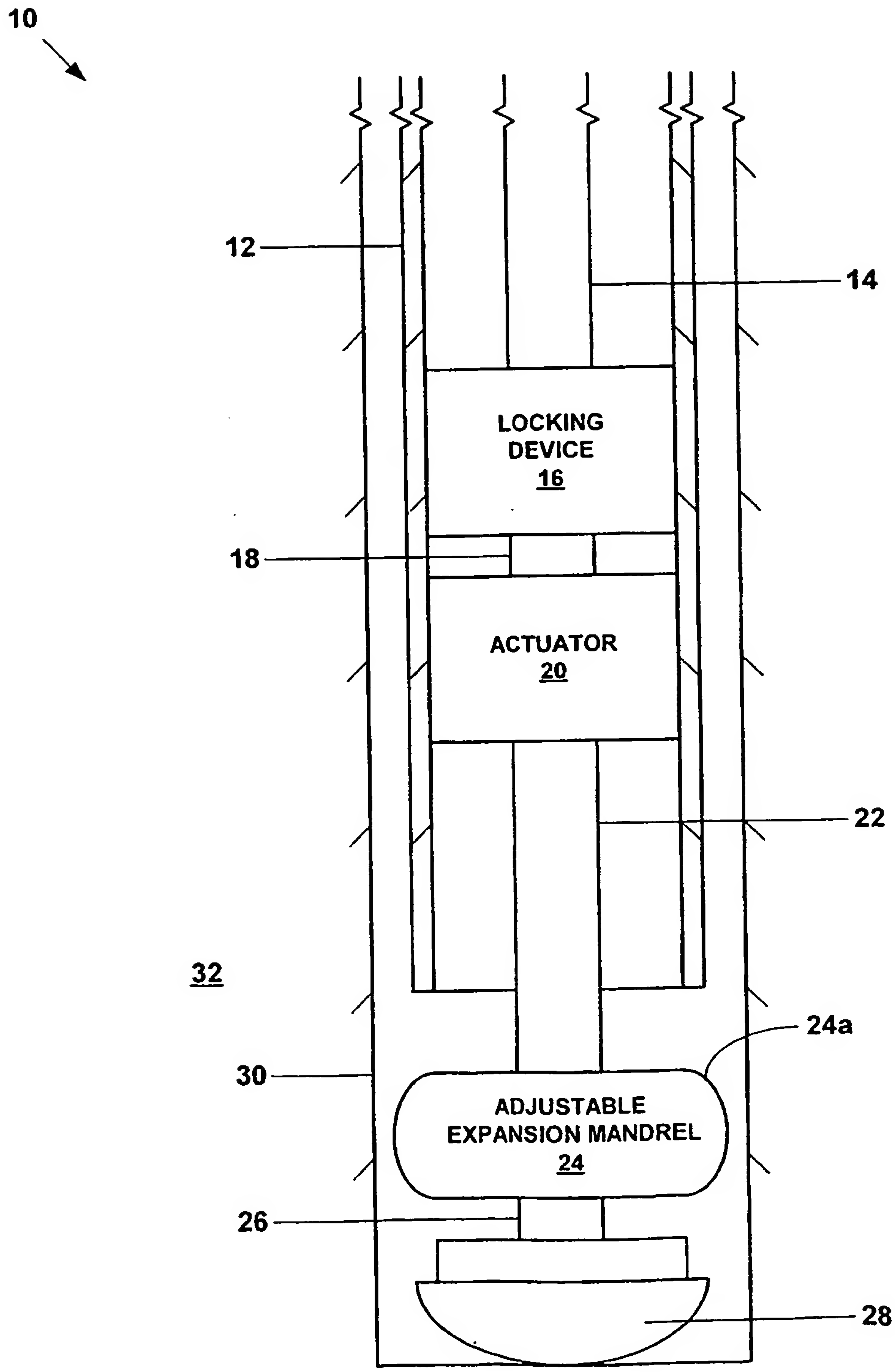
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Fig. 3

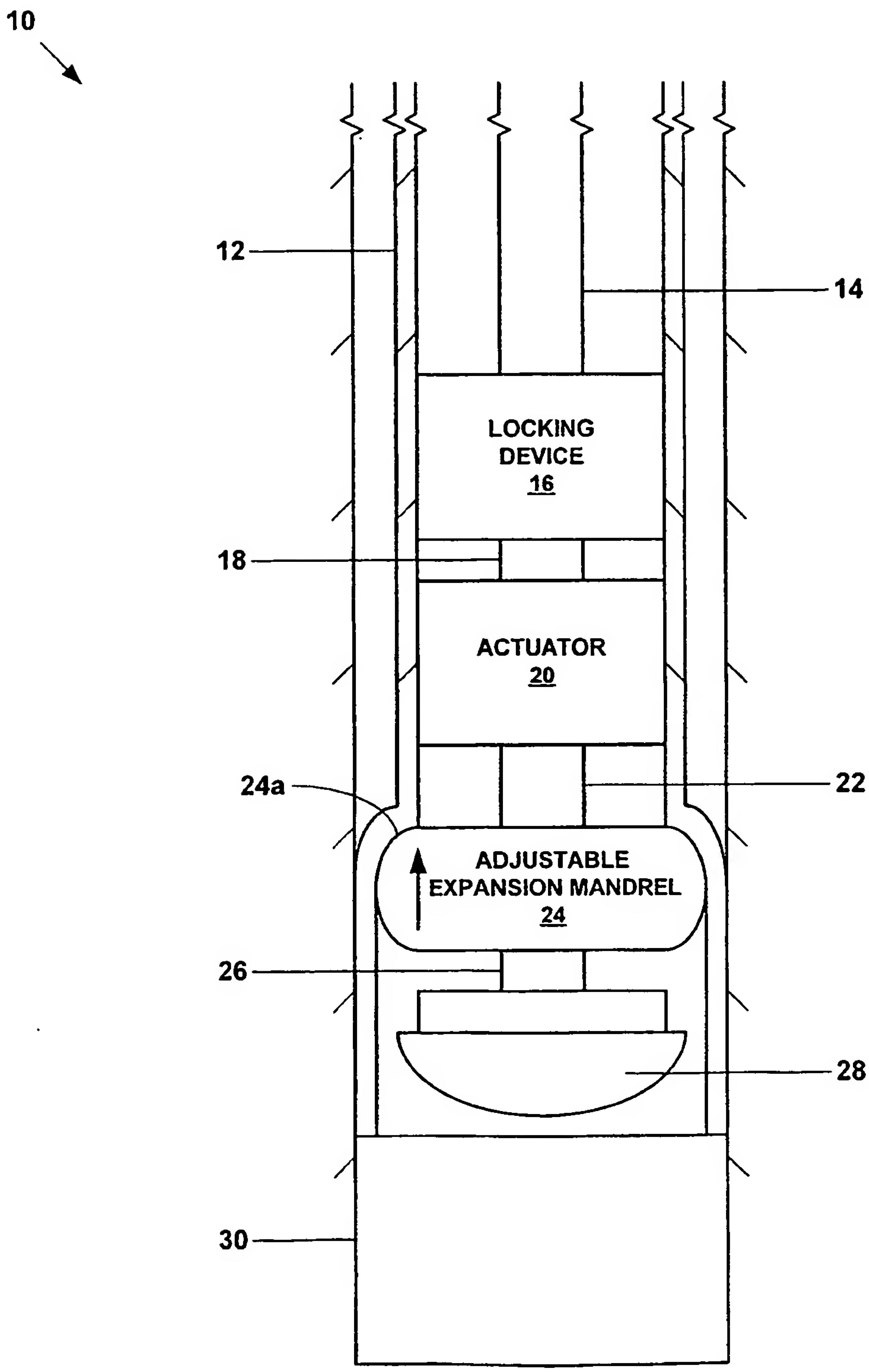
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Fig. 4

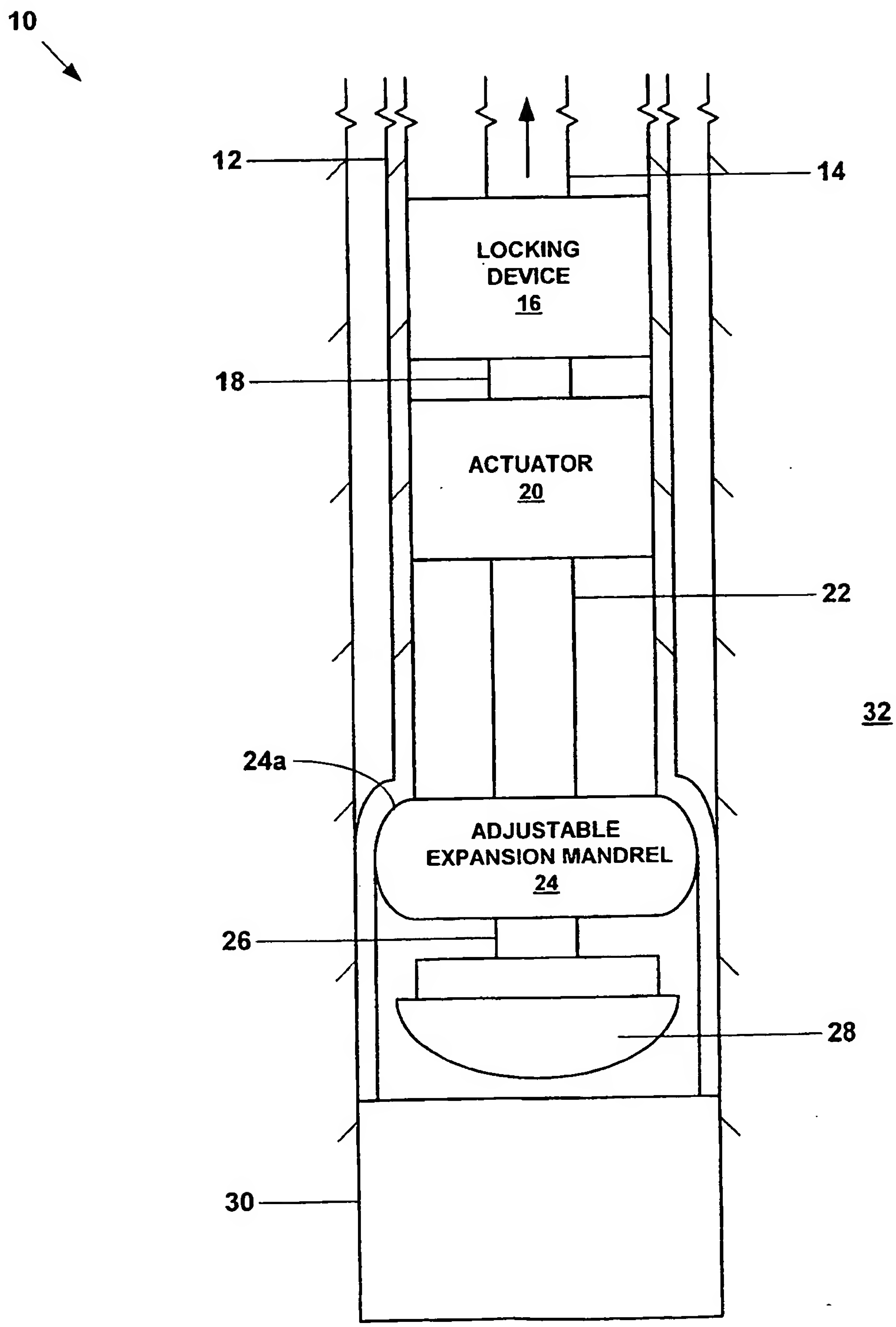
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Fig. 5

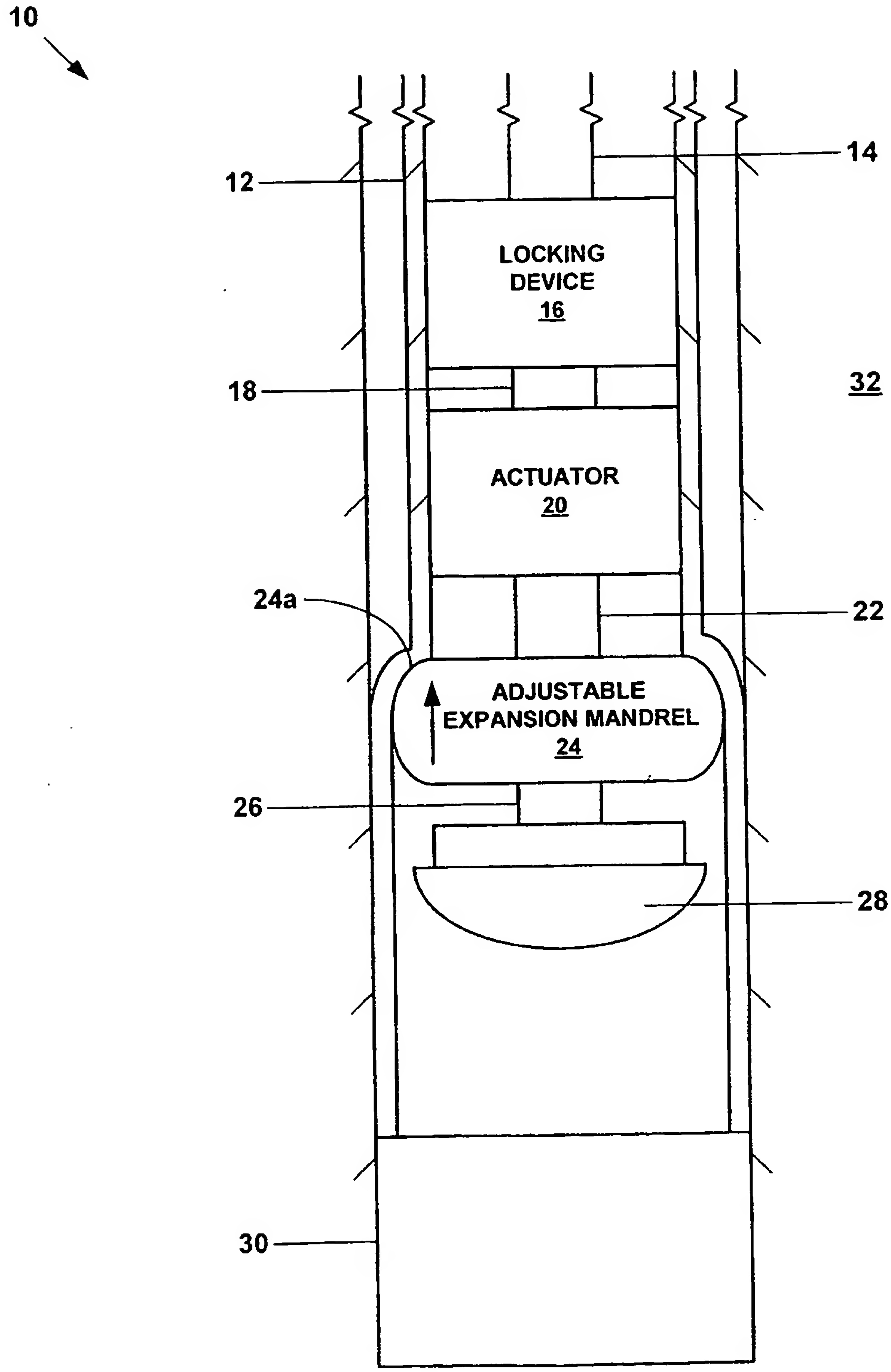
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Fig. 6

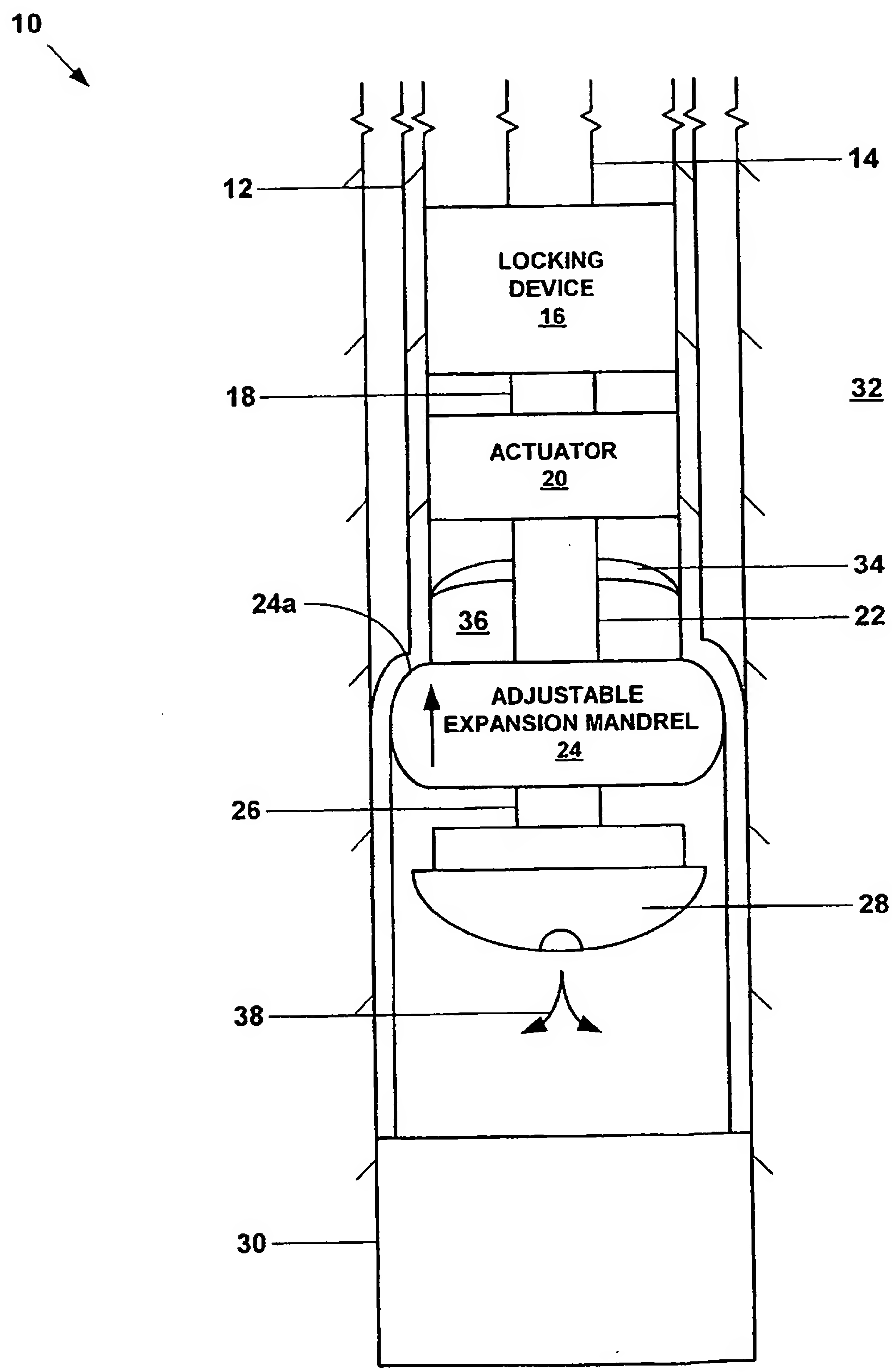
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Fig. 6a

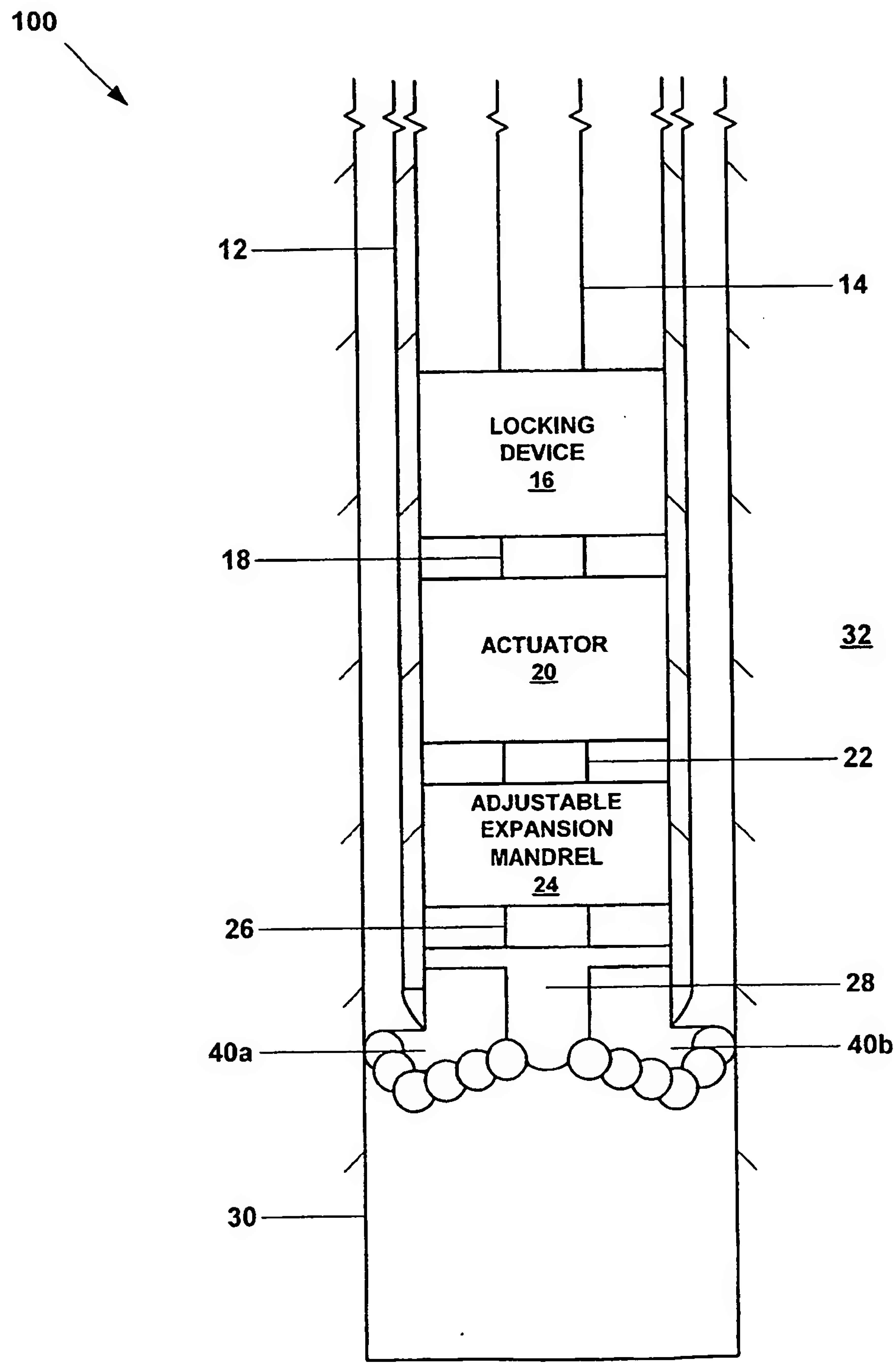
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Fig. 7

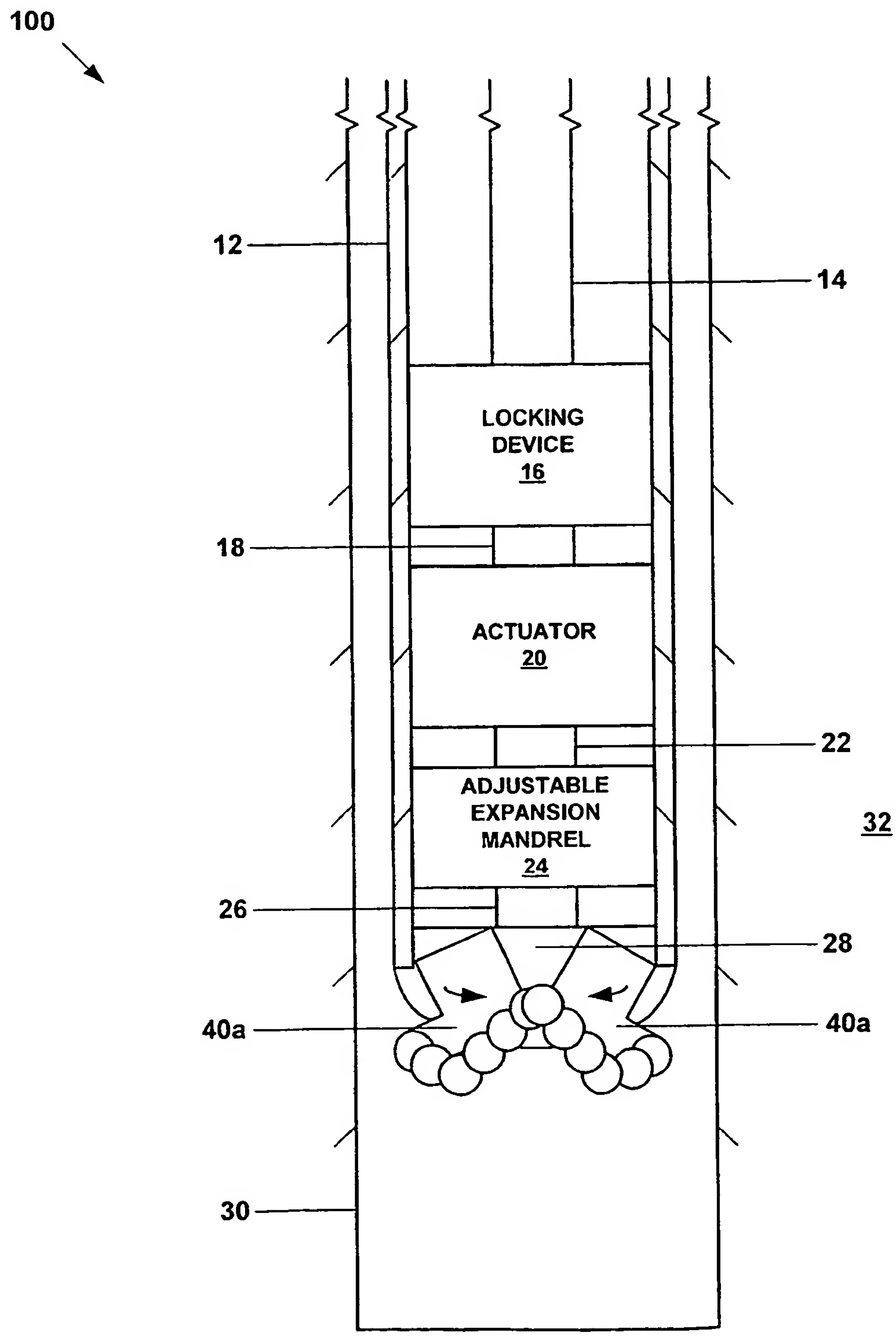
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Fig. 8

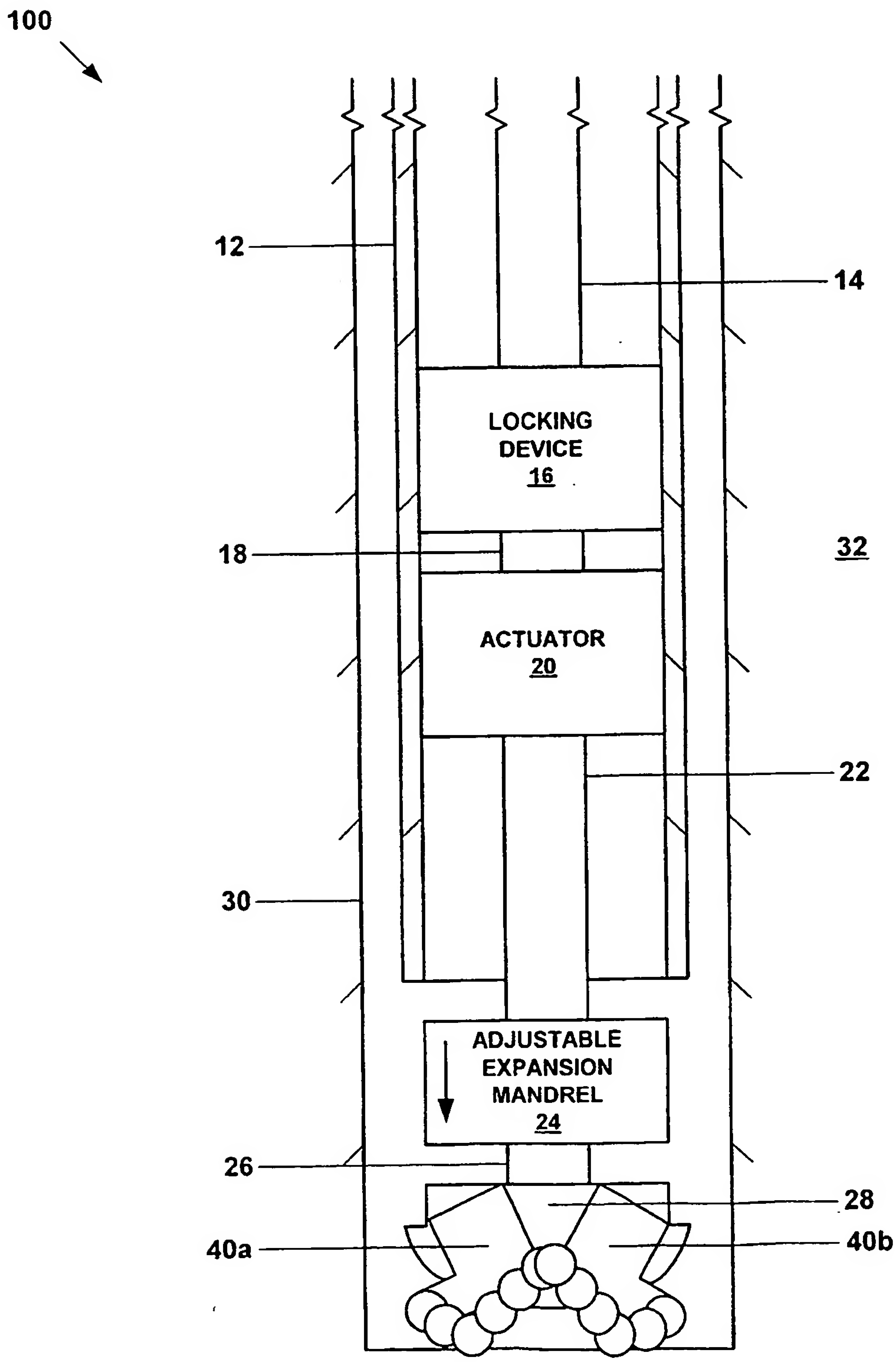
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Fig. 9

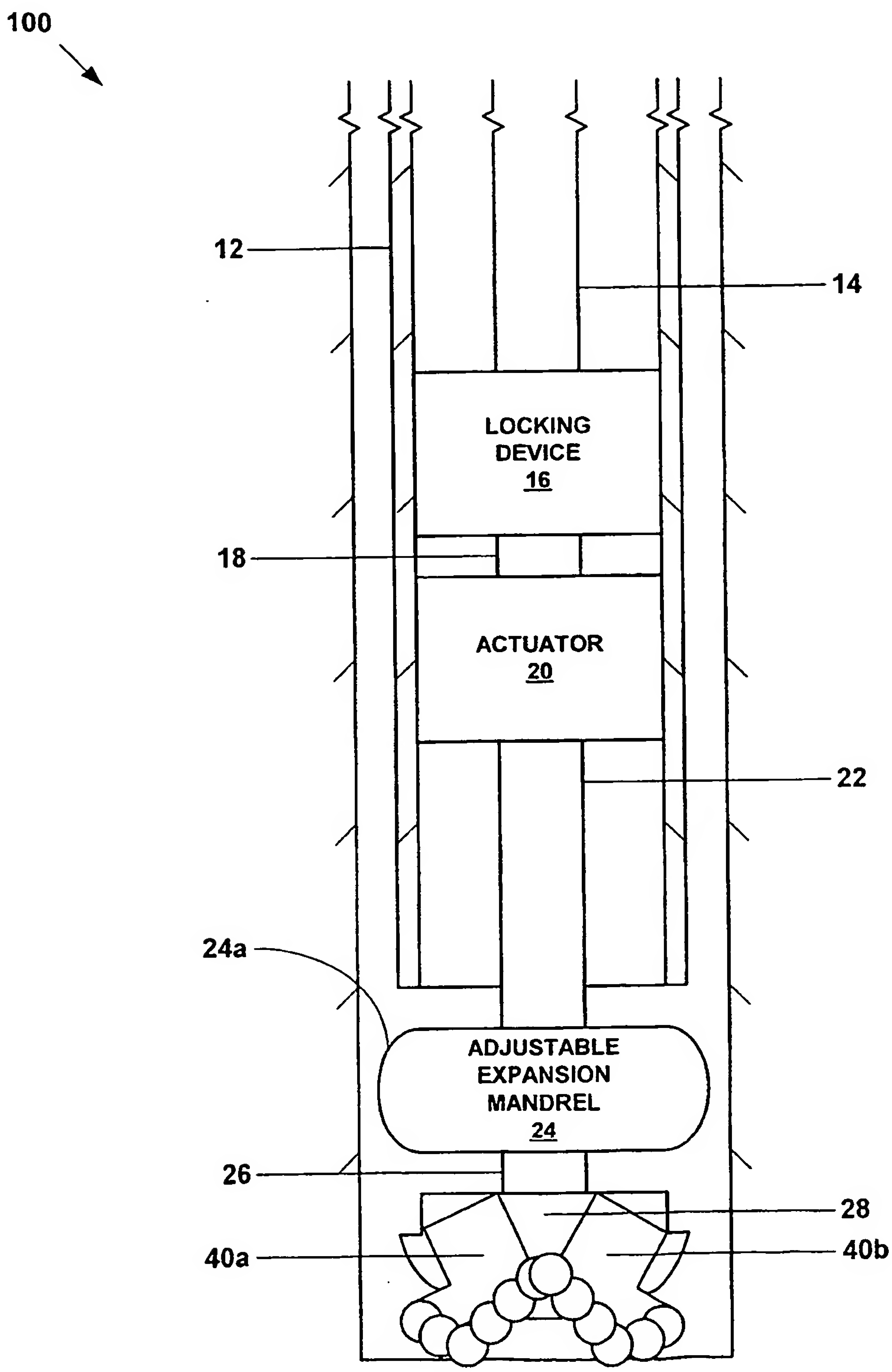
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Fig. 10

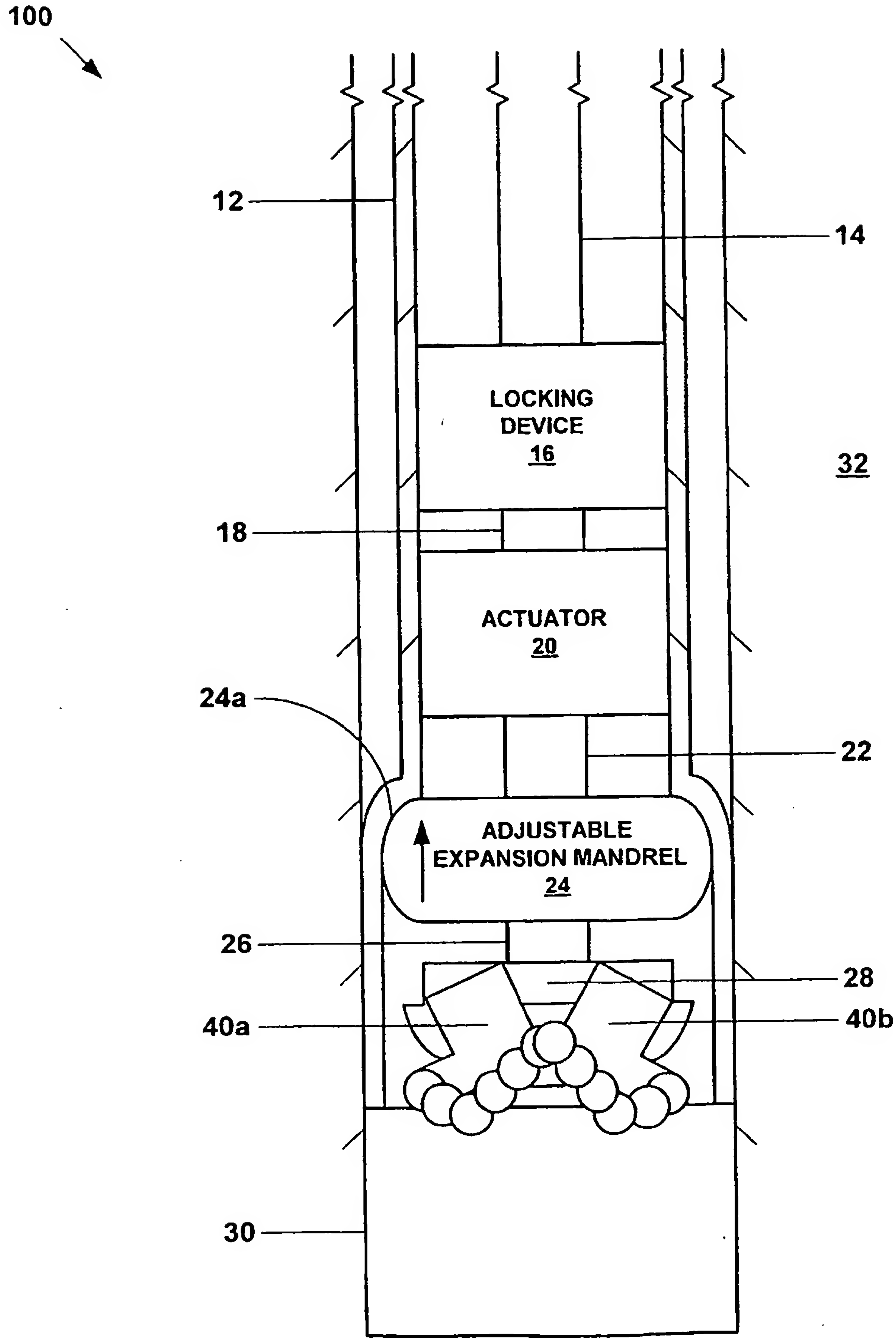
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Fig. 11

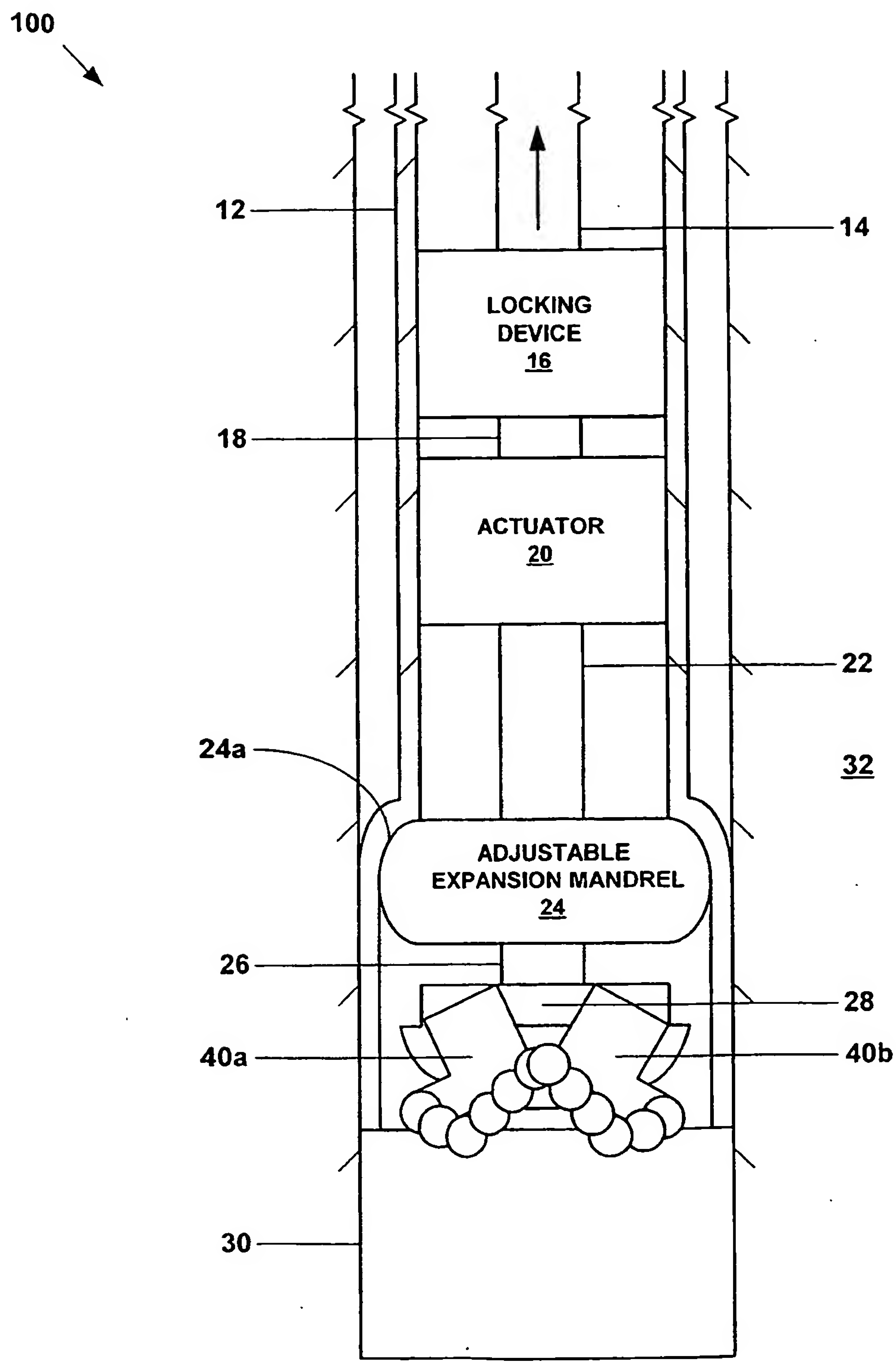
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Fig. 12

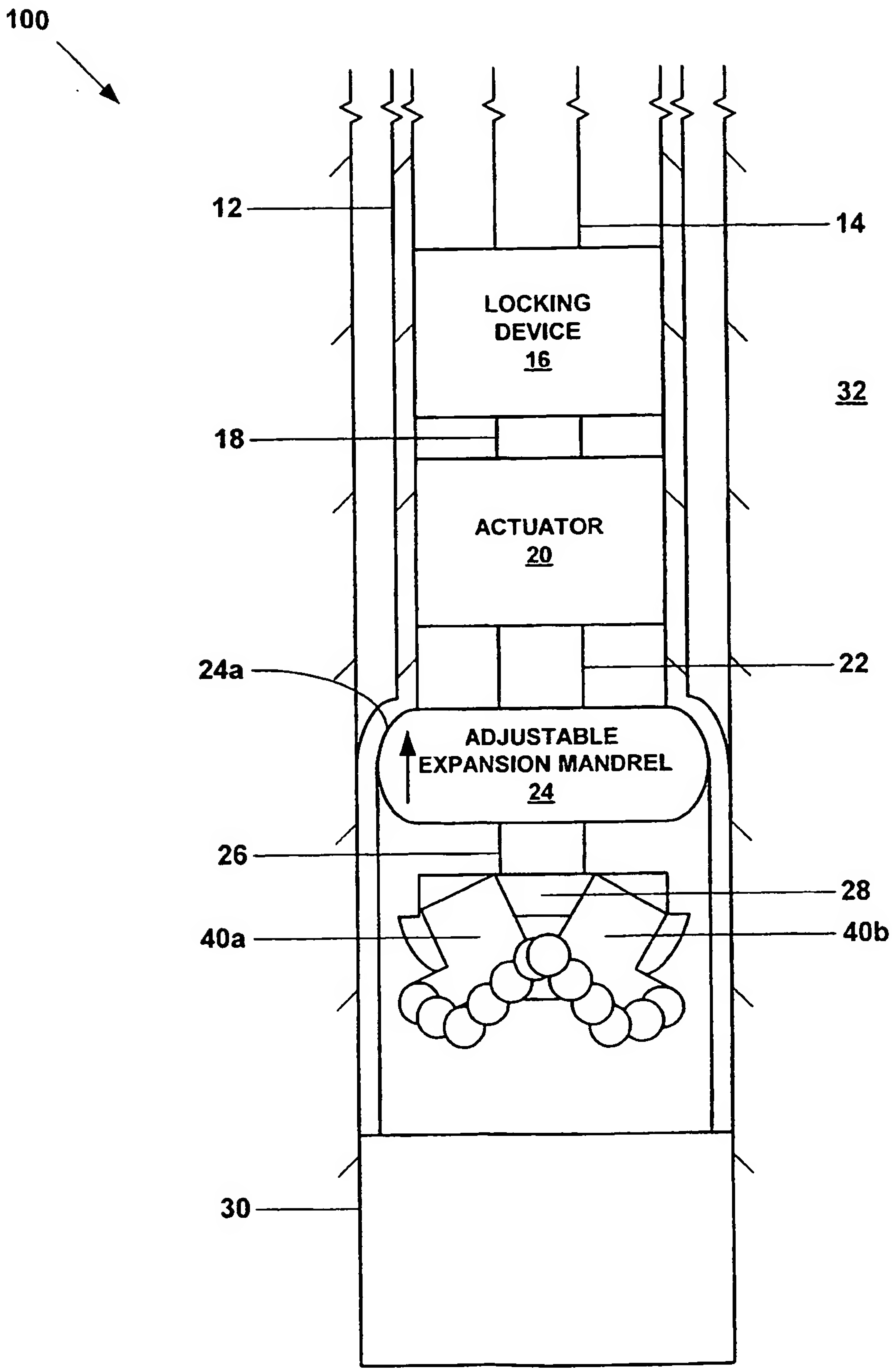
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Fig. 13

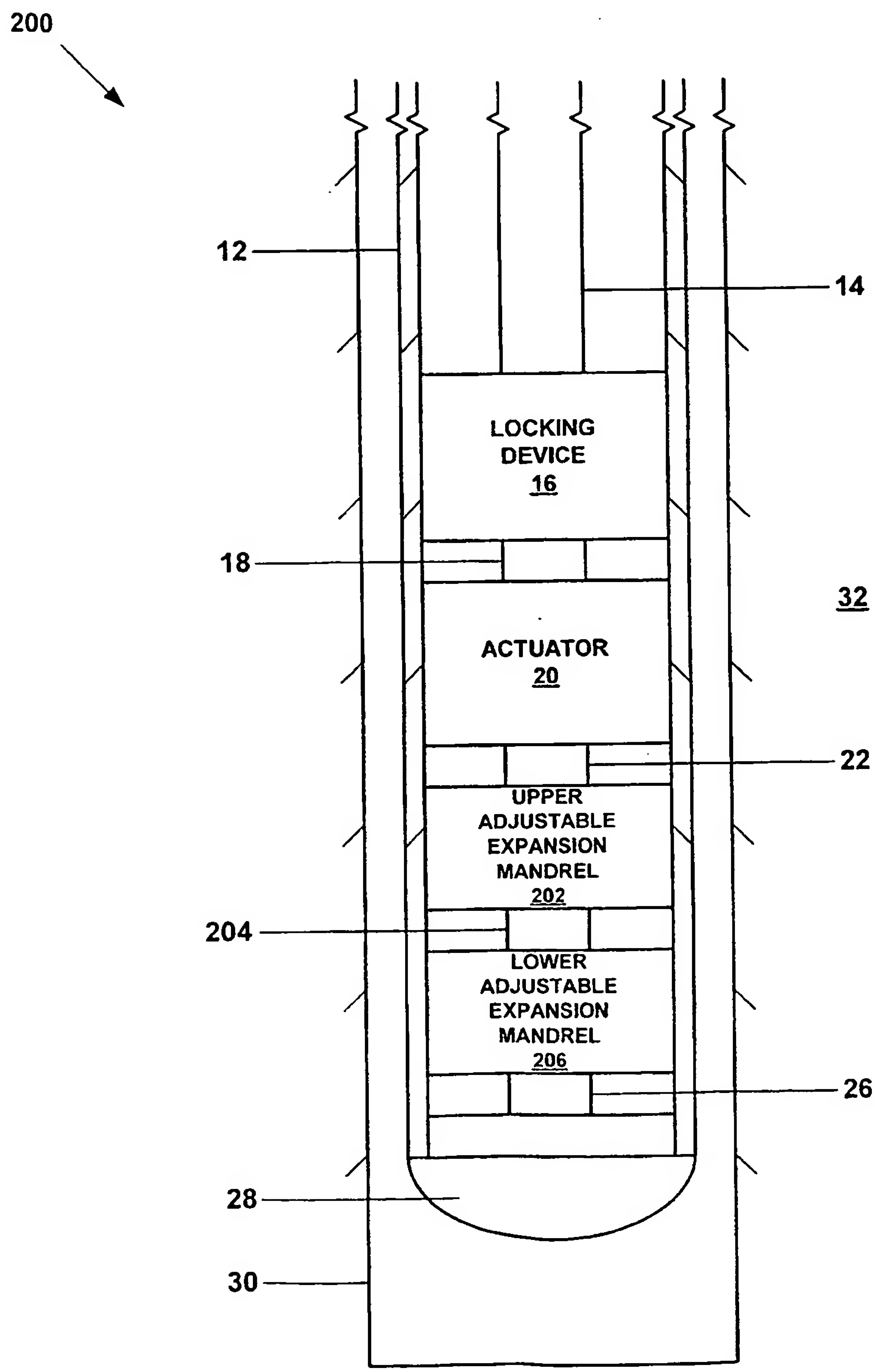
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Fig. 14

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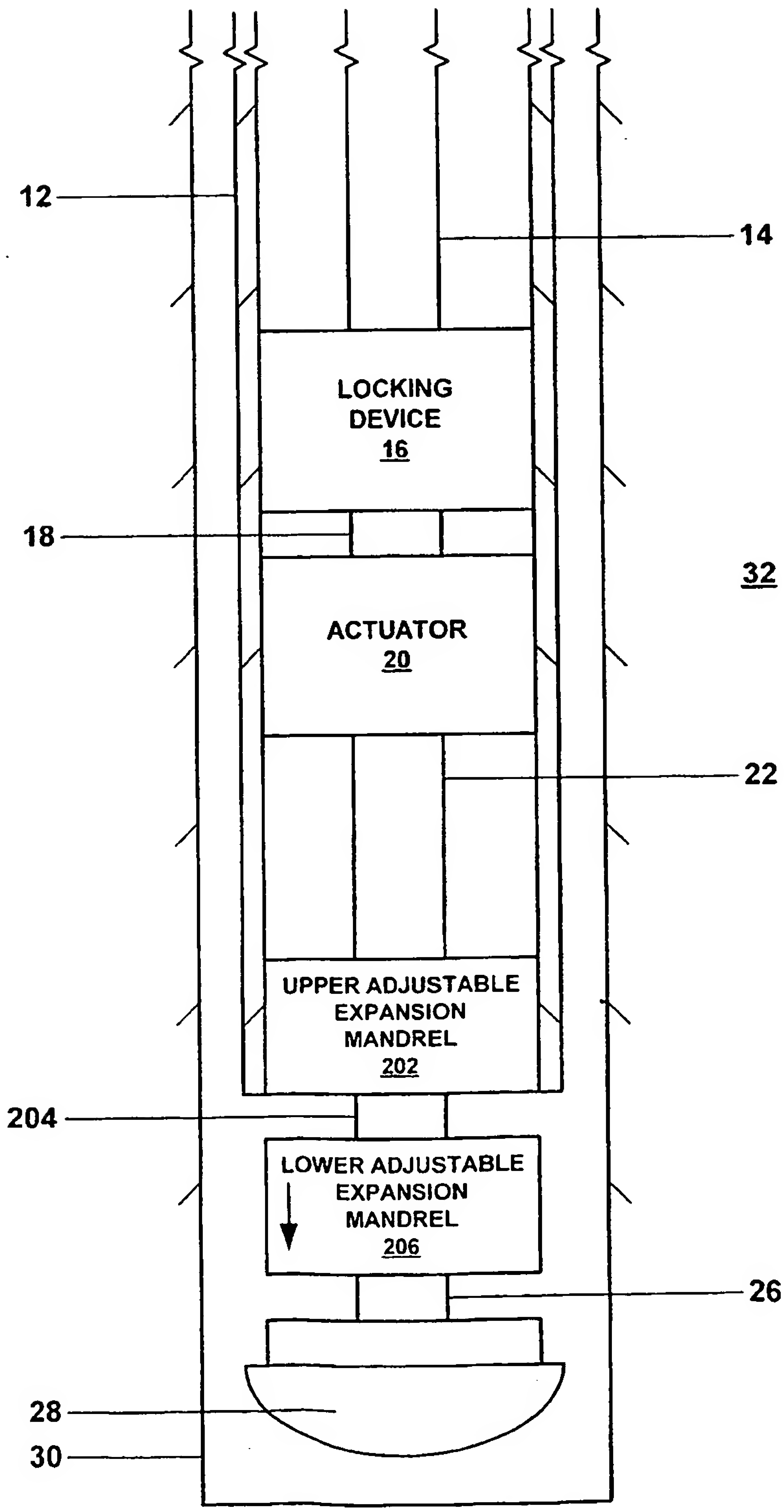
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Fig. 15

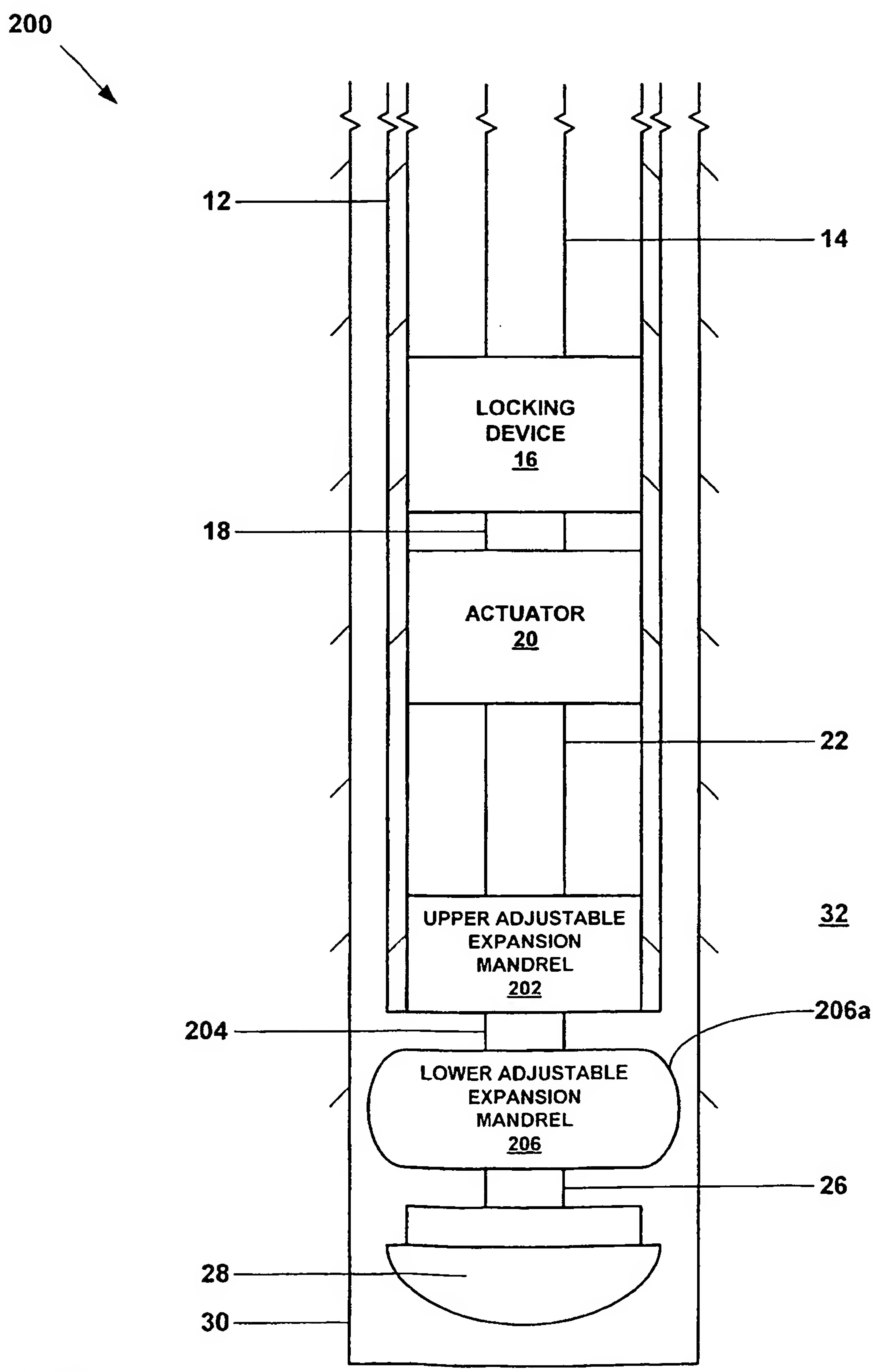
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Fig. 16

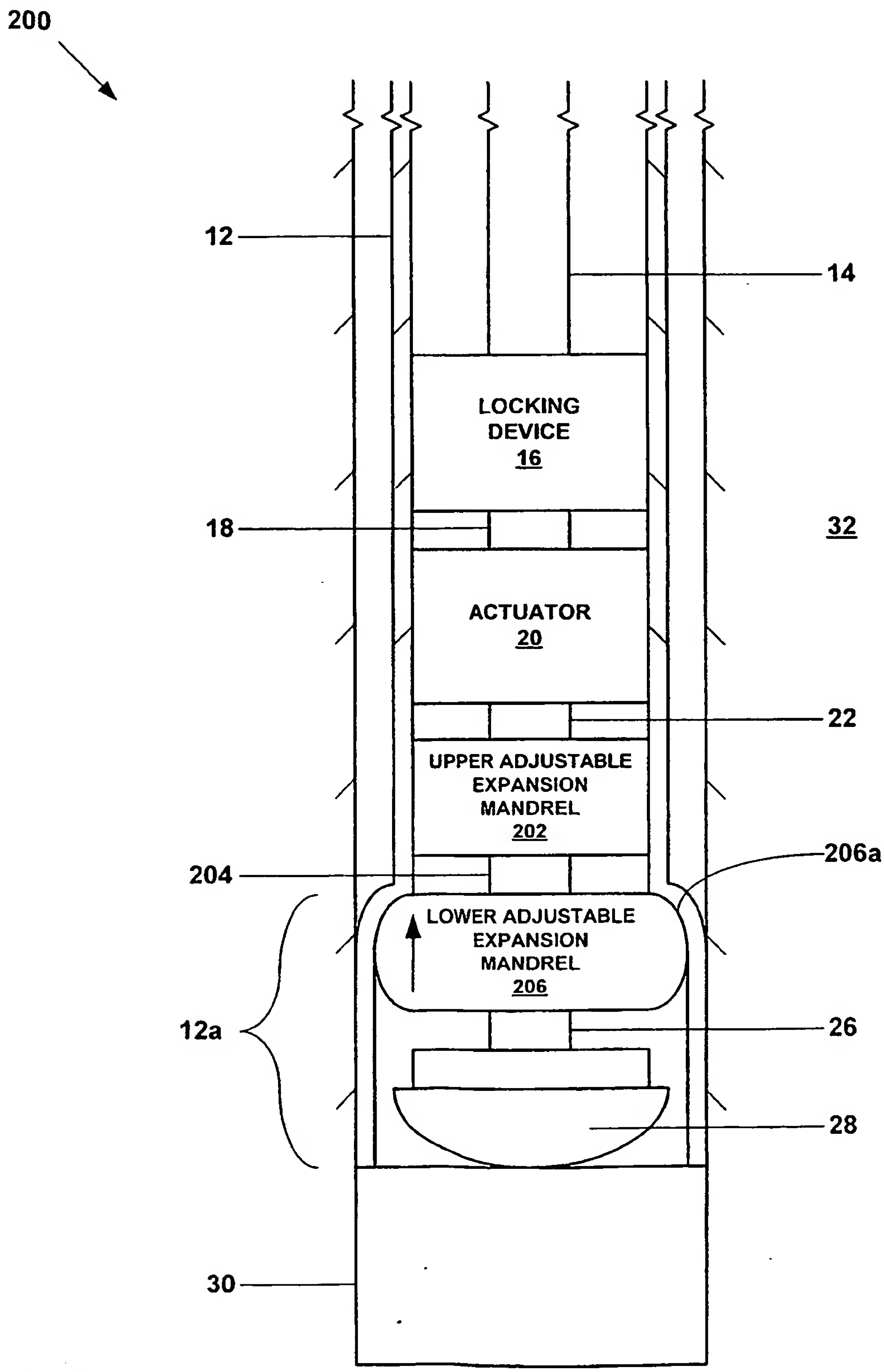
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Fig. 17

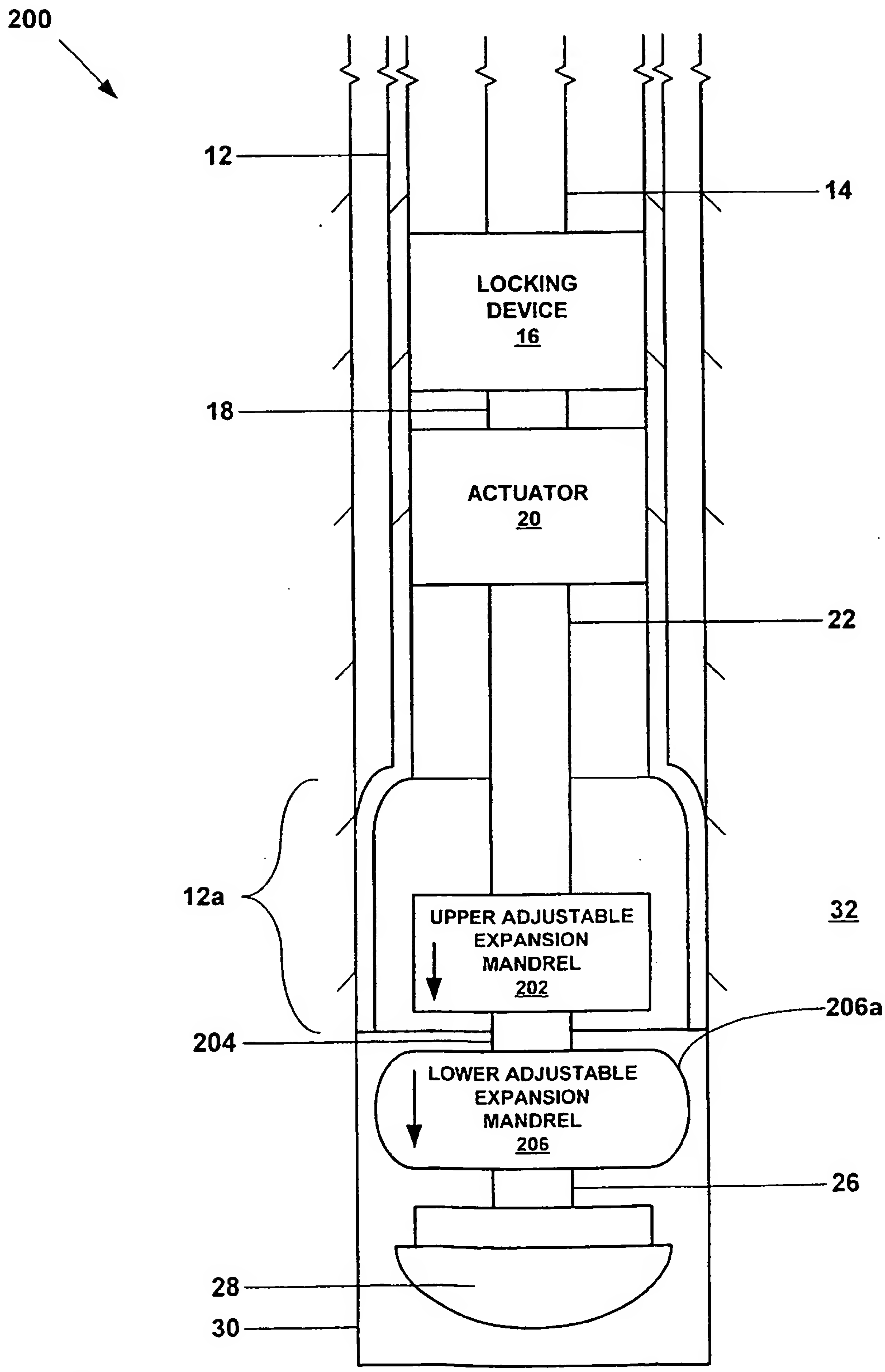
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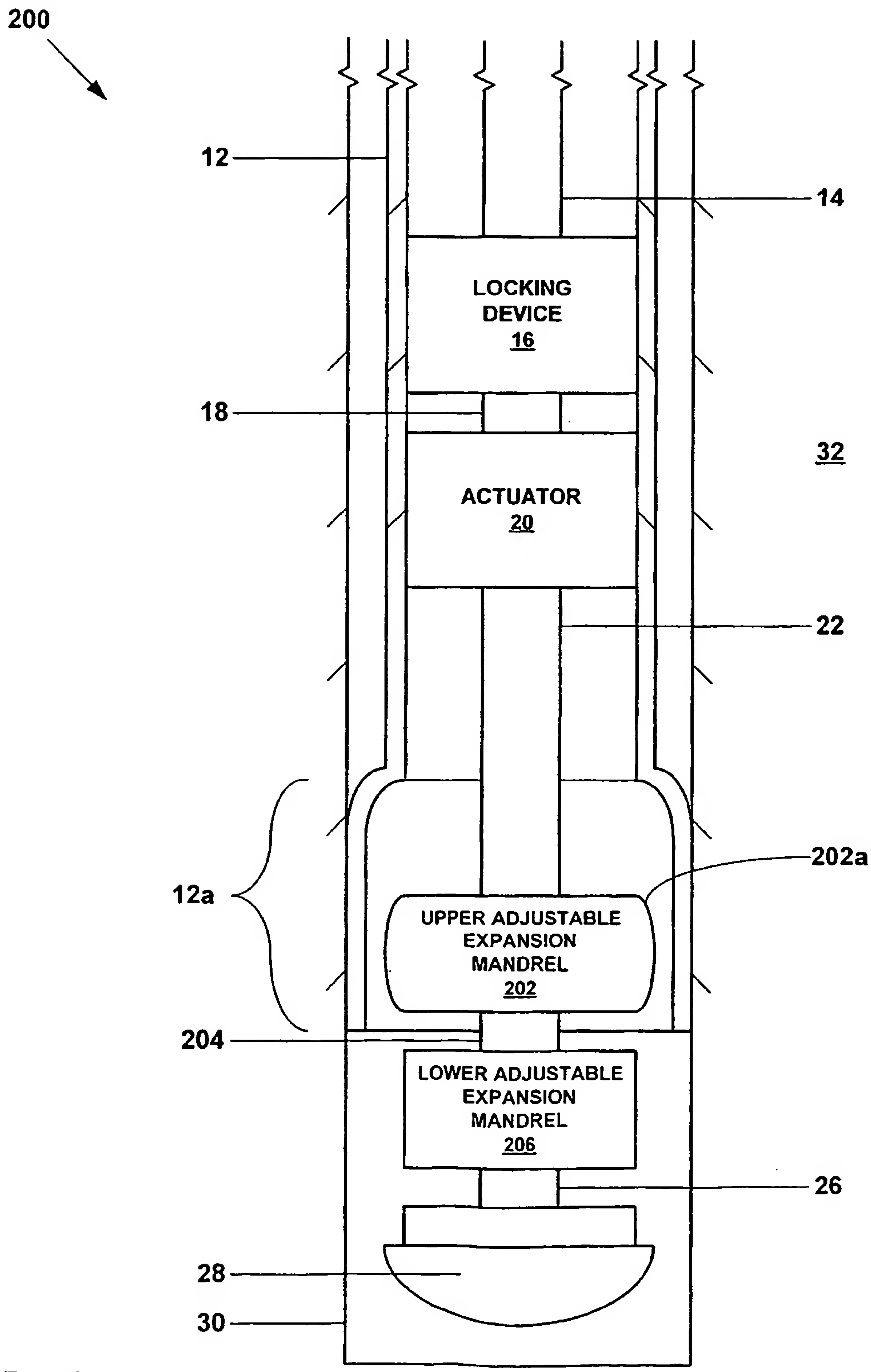
Fig. 18



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30

Fig. 19

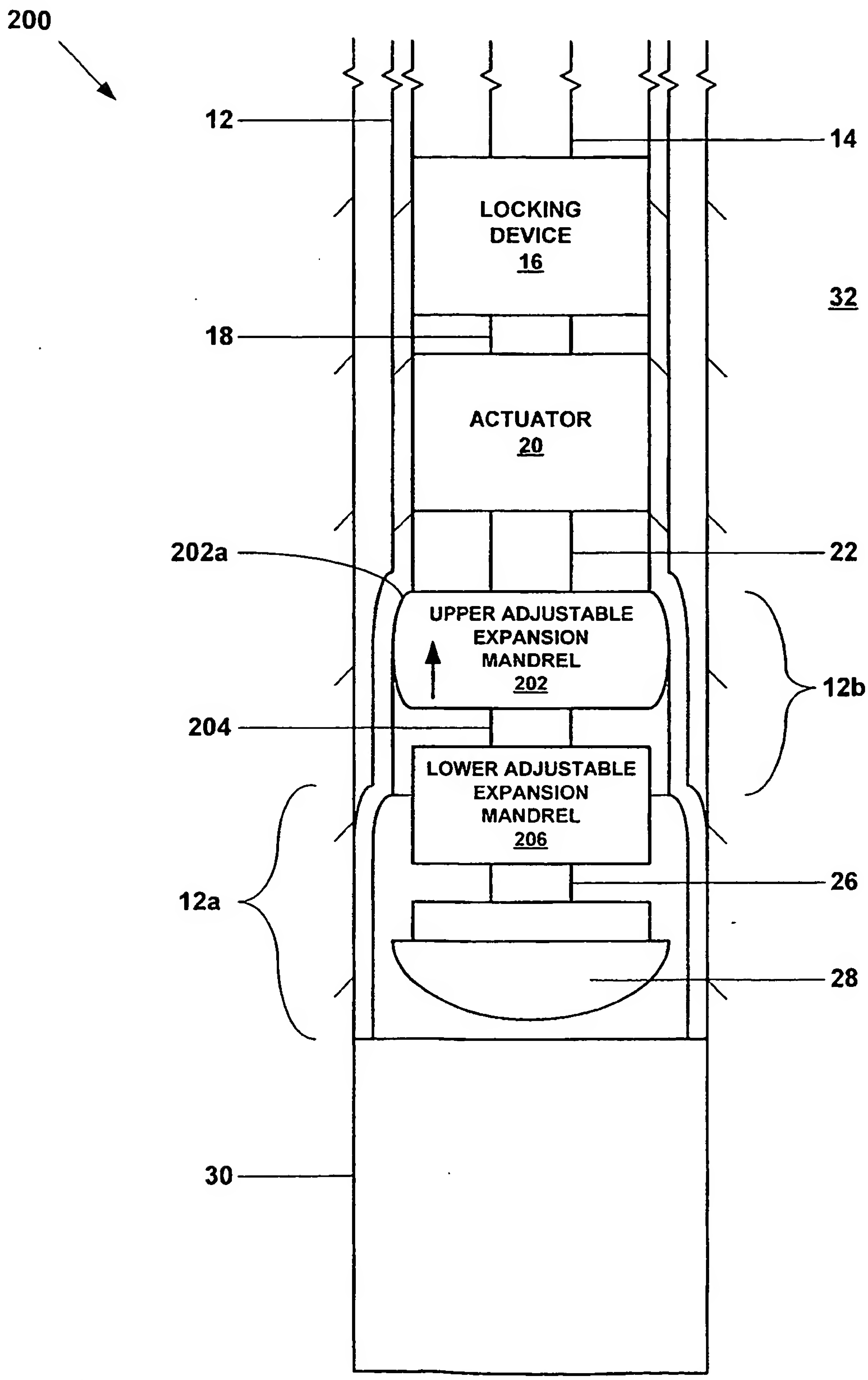

200
12
14
LOCKING DEVICE 16
32
18
ACTUATOR 20
202a
22
UPPER ADJUSTABLE EXPANSION MANDREL 202
12b
204
LOWER ADJUSTABLE EXPANSION MANDREL 206
26
12a
28
30

Fig. 20

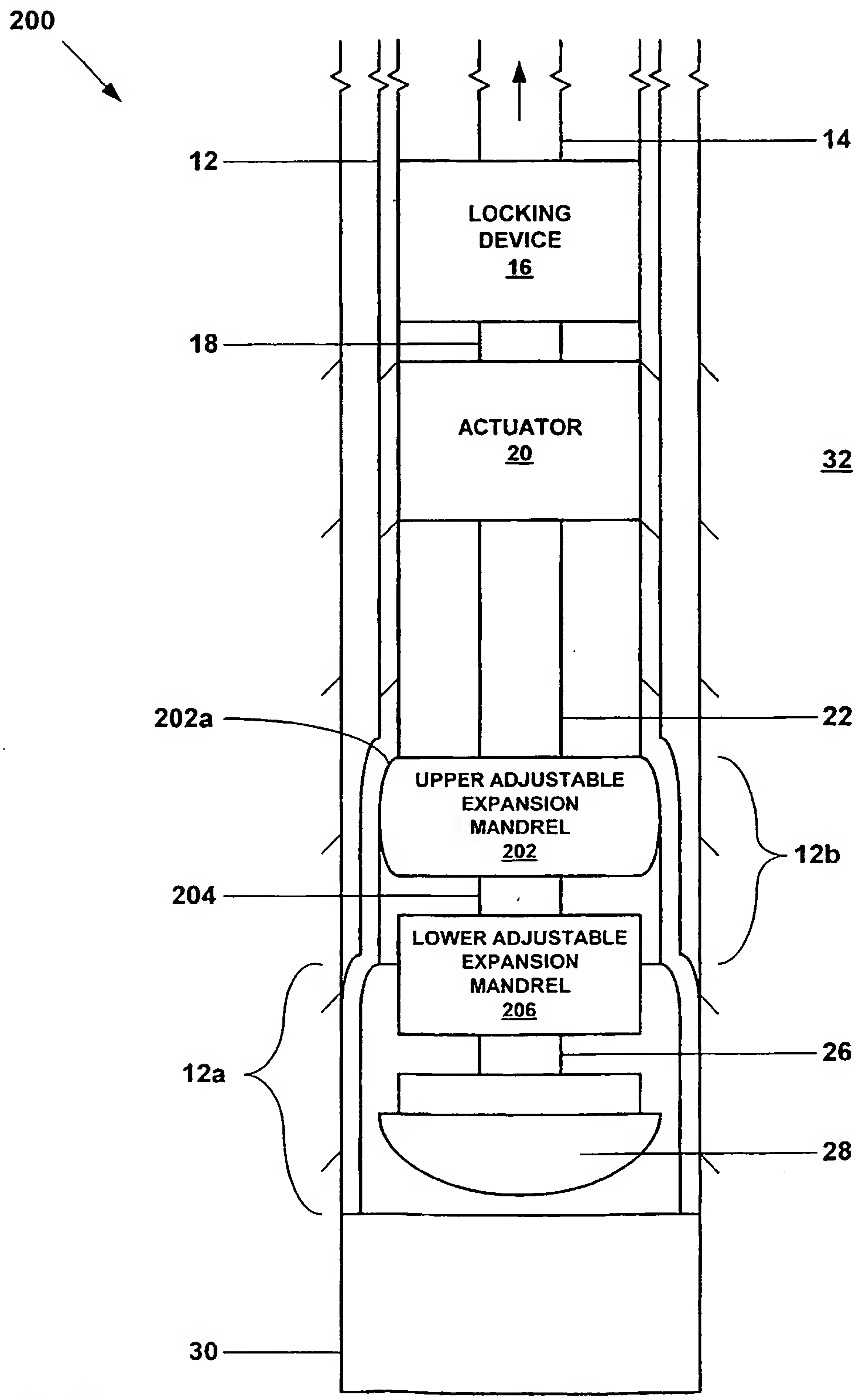

200
14
12
LOCKING
DEVICE
16
18
ACTUATOR
20
32
202a
22
UPPER ADJUSTABLE
EXPANSION
MANDREL
202
12b
204
LOWER ADJUSTABLE
EXPANSION
MANDREL
206
12a
26
28
30

Fig. 21

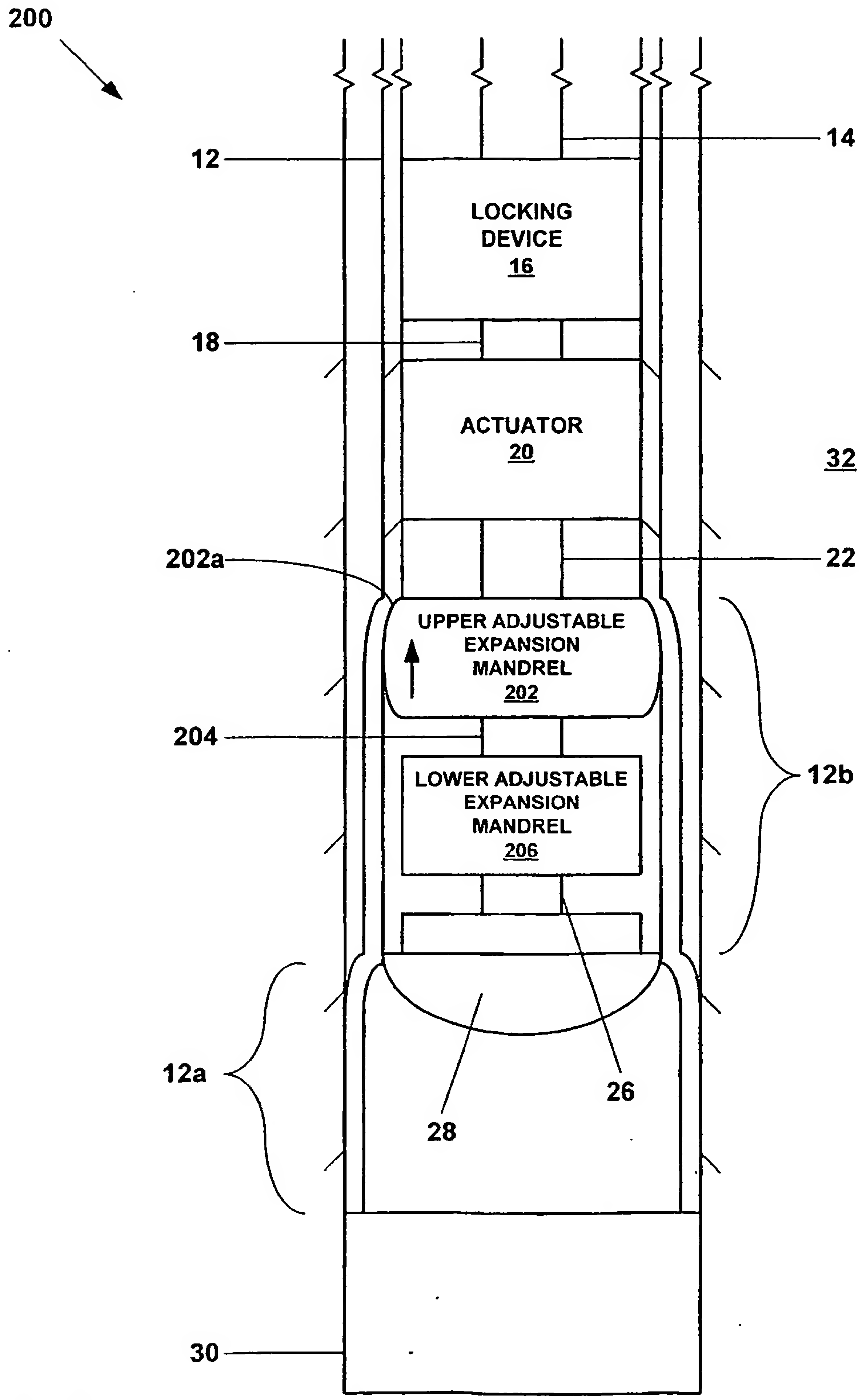

200
12
14
LOCKING
DEVICE
16
18
ACTUATOR
20
32
202a
22
UPPER ADJUSTABLE
EXPANSION
MANDREL
202
204
LOWER ADJUSTABLE
EXPANSION
MANDREL
206
12b
12a
26
28
30

Fig. 22

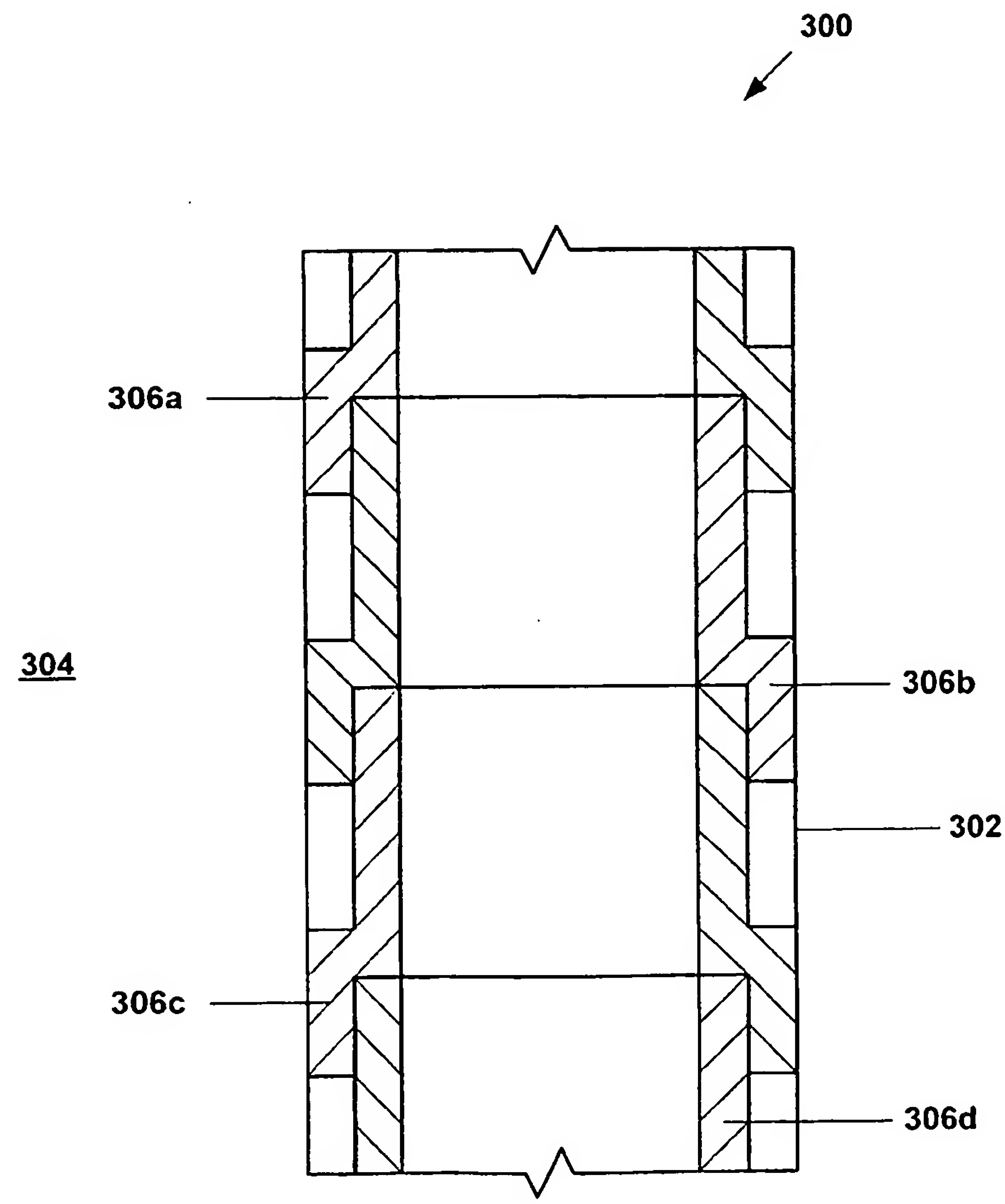


Fig. 23

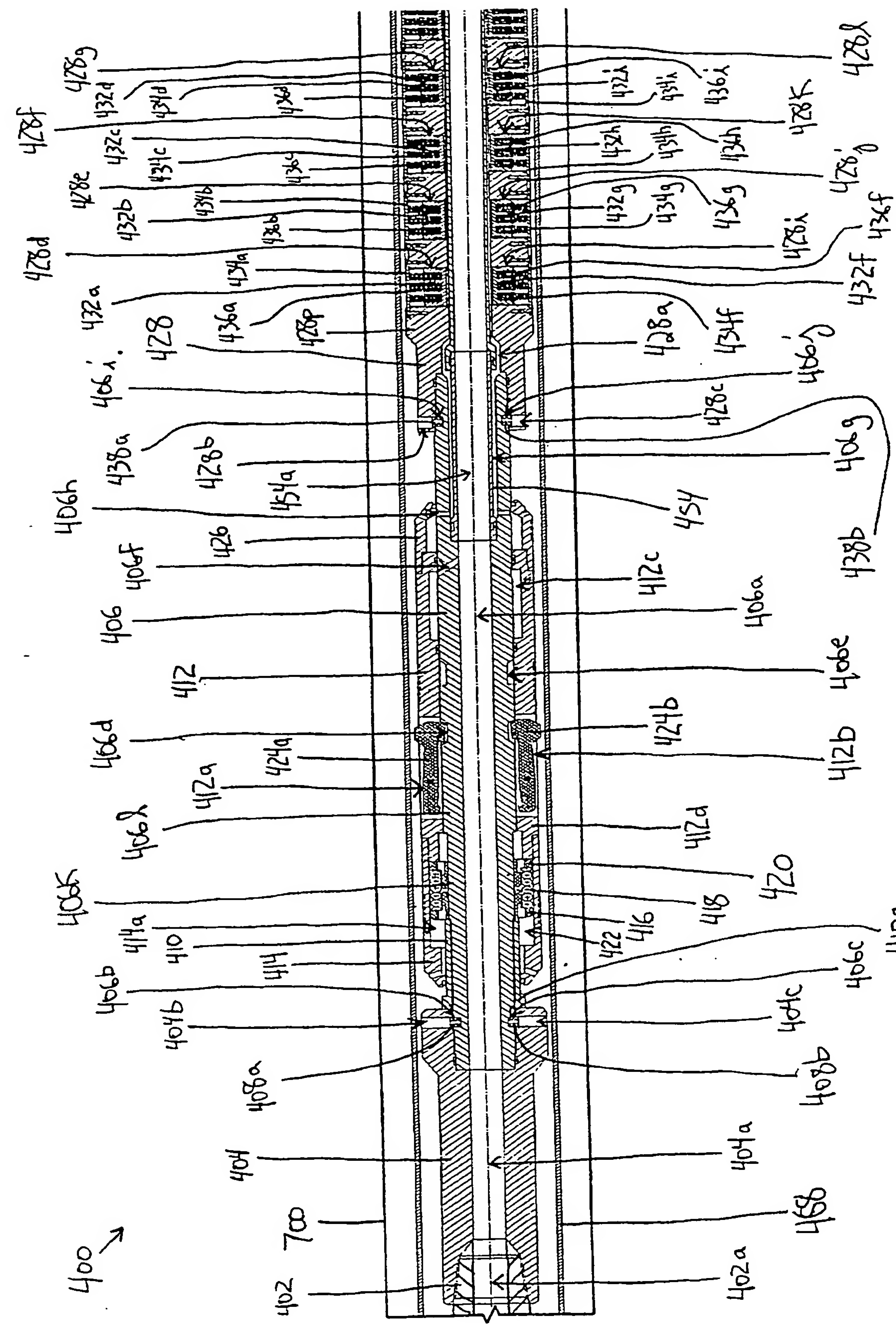

400
402
402a
404
404a
404b
404c
406
406a
406b
406c
406d
406e
406f
406g
406h
408a
408b
410
410a
412
412a
412b
412c
412d
414
414a
416
418
420
422
424a
424b
426
428
428a
428b
428c
432a
454
454a
700
438a
438b

Fig. 24a

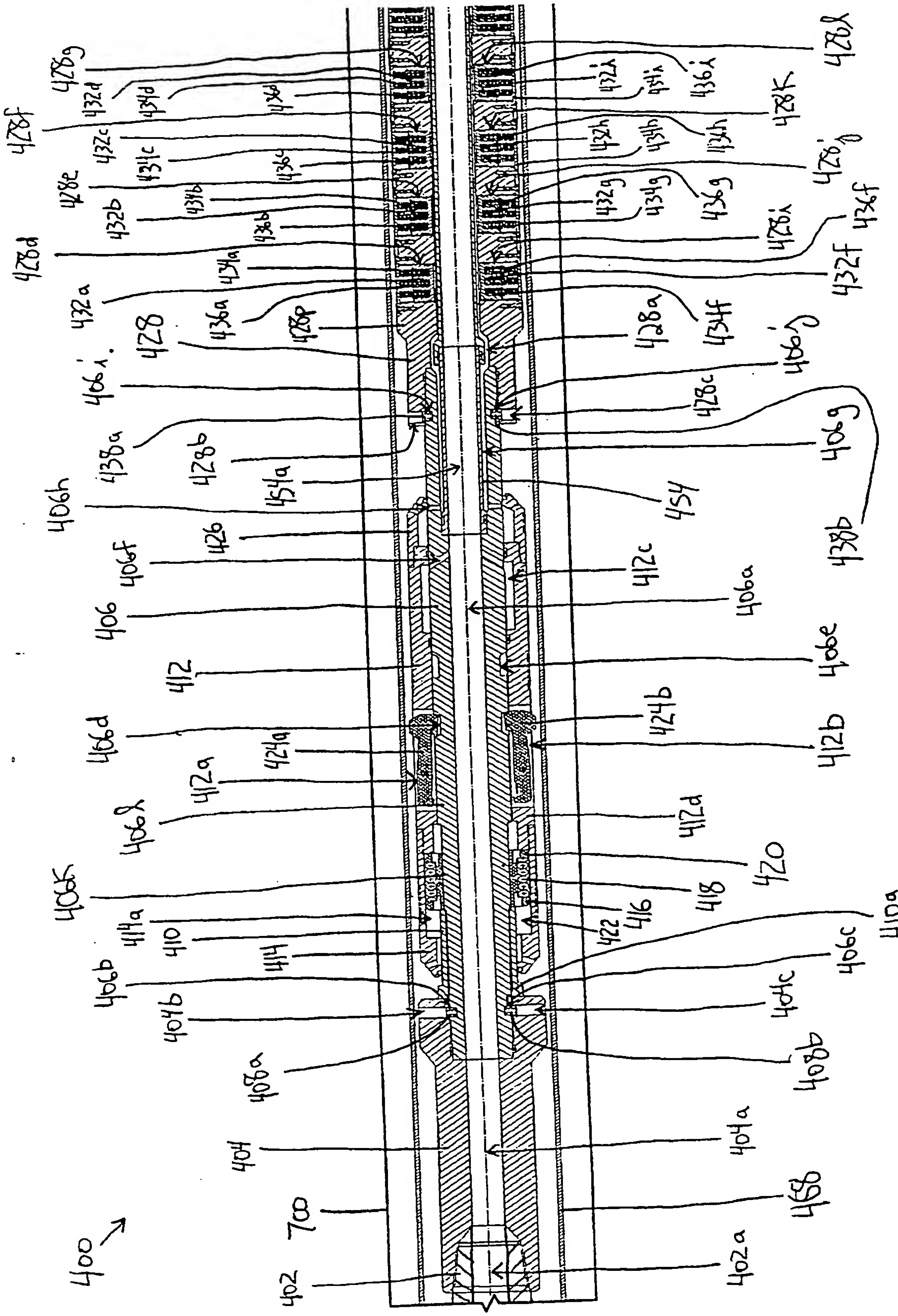

400
402
402a
404
404a
404b
404c
406
406a
406b
406c
406d
406e
406f
406g
406h
406k
408a
408b
410
410a
412
412a
412b
412c
412d
414
414a
416
418
420
422
424a
424b
426
428
428a
428b
428c
428d
428e
428f
428g
428i
428j
428k
428l
432a
432b
432c
432d
432f
432g
432h
432i
434a
434b
434c
434d
434f
434g
434h
434i
436a
436b
436c
436d
436f
436g
436h
436i
438a
438b
454
454a
458
700

Fig. 24a

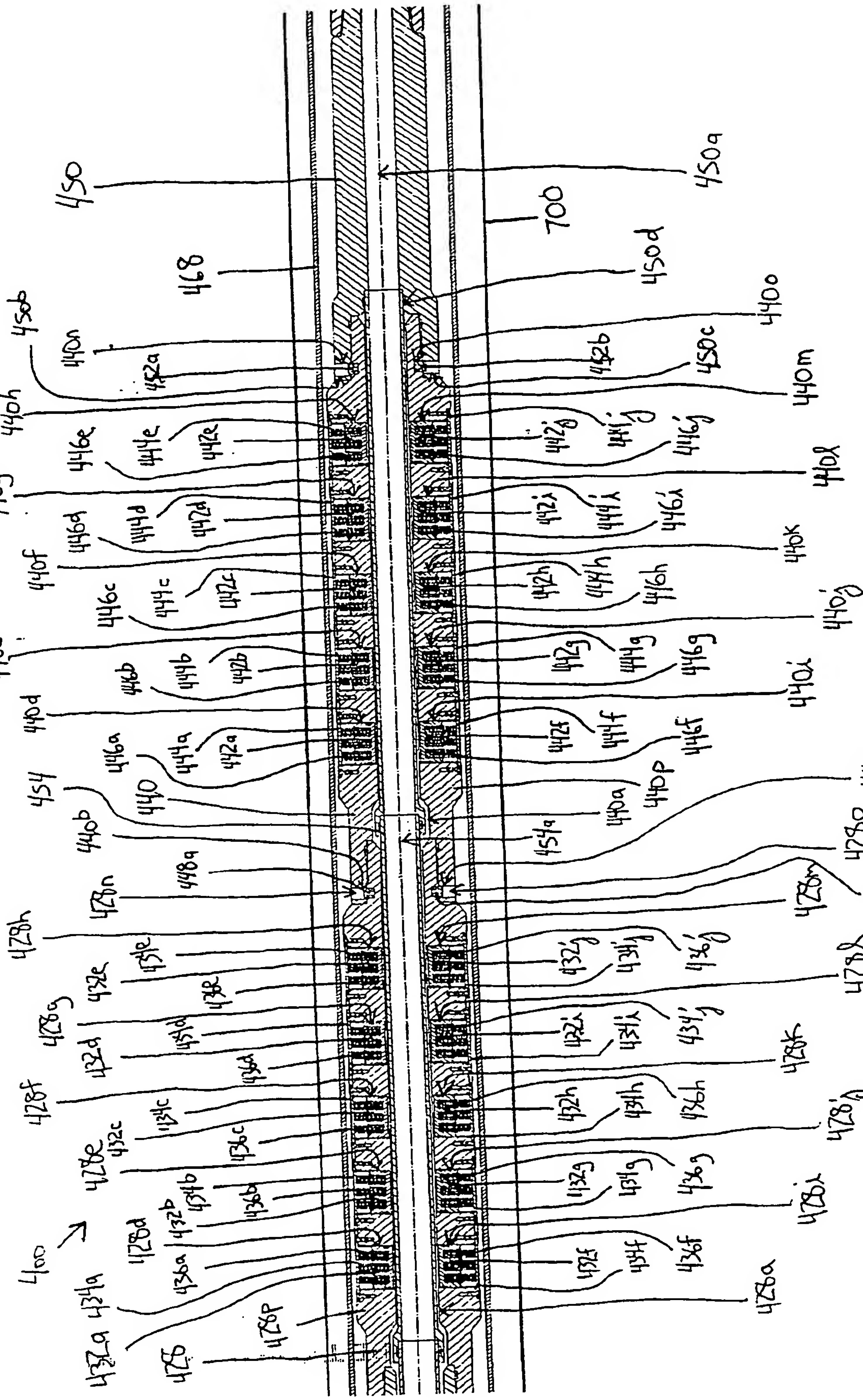


Fig. 24b

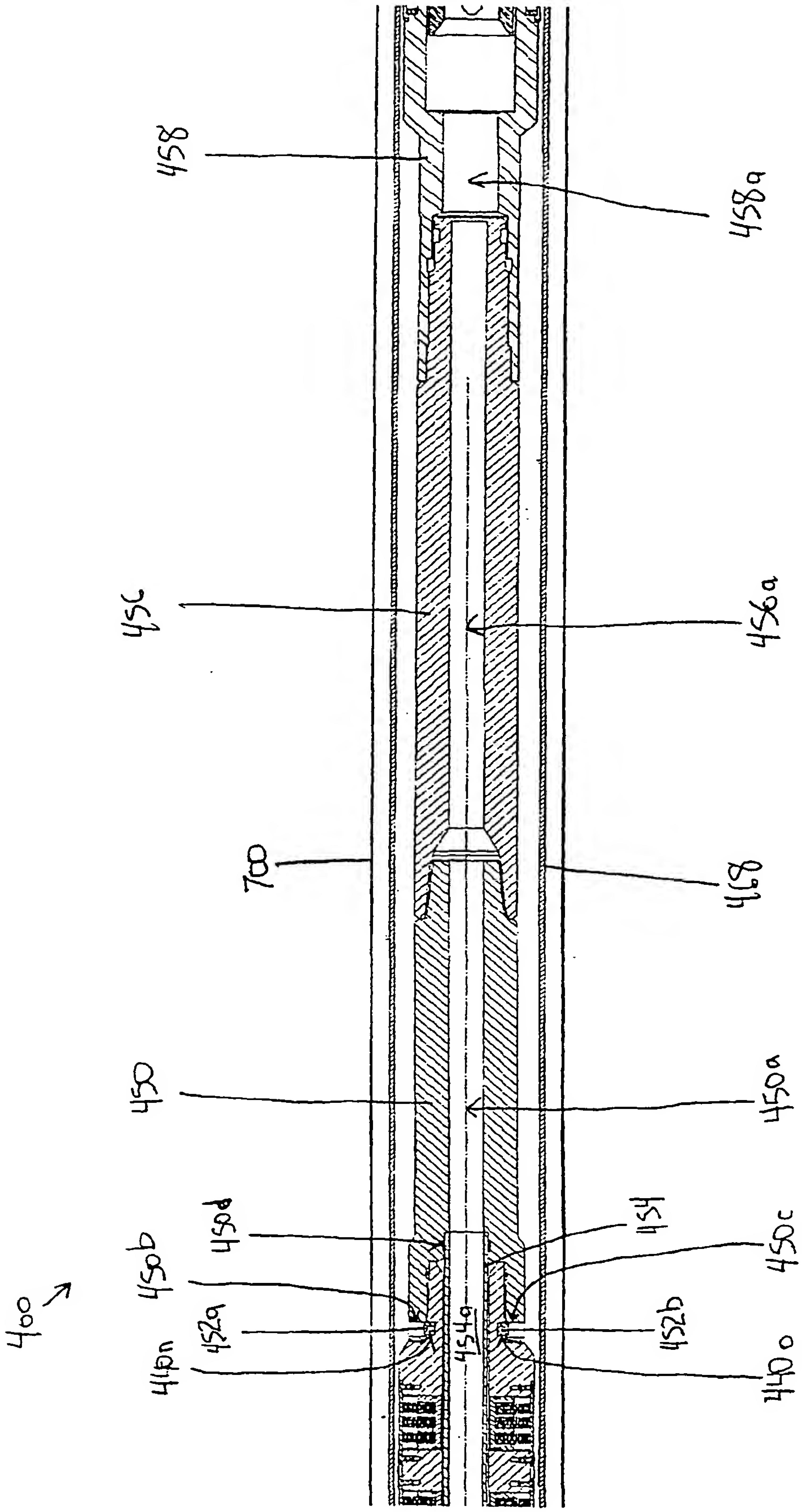
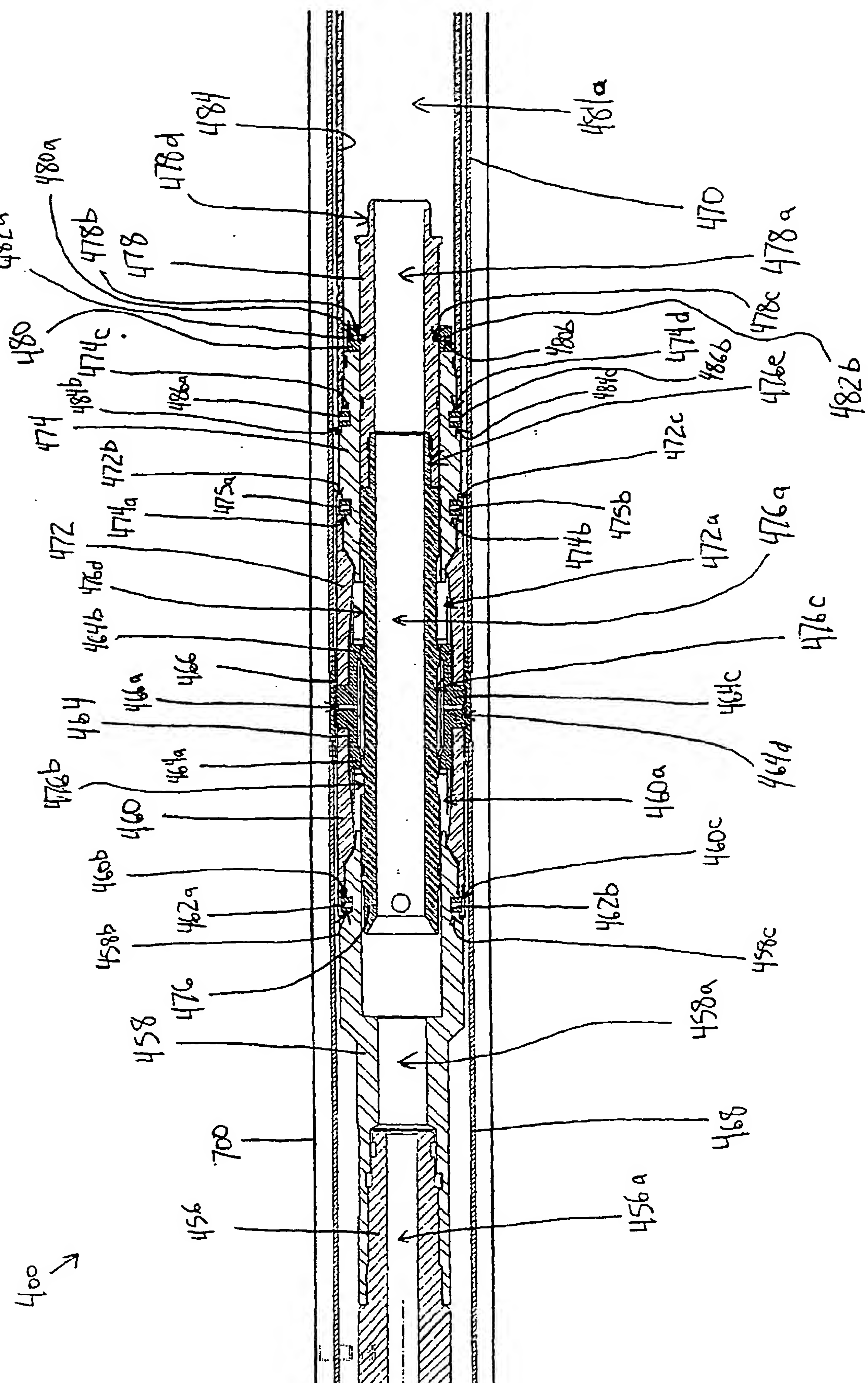

458
458a
456a
700
450
450a
450b
450d
454
450c
452a
452b
454a
440o
400

Fig. 24c



400
456
456a
700
468
458
458a
476
458b
458c
462a
462b
460b
460c
460
460a
476b
464a
464
464d
466a
464c
466
476c
464b
476d
476a
472
472a
474a
474b
475a
475b
472b
472c
474
484b
476e
486a
484a
474c
474d
486b
480
486
482a
482b
478b
478c
478
478a
480a
478d
470
484
461a

Fig. 24d

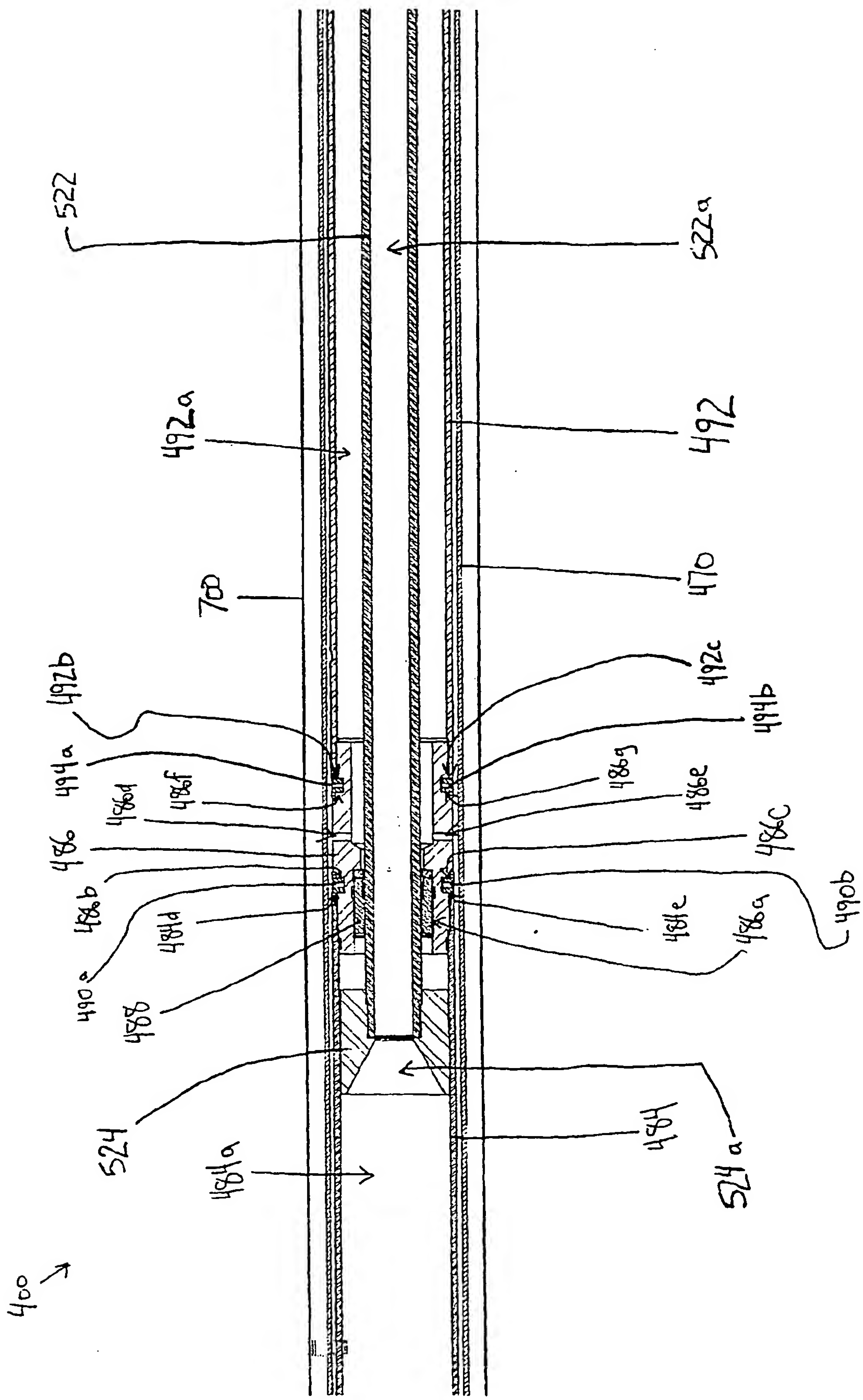

400
522
522a
492a
492
700
470
492b
492c
494a
494b
486d
486f
486g
486e
486c
486
486b
490b
484d
484e
486a
490a
488
524
484a
484
524a

Fig. 24e

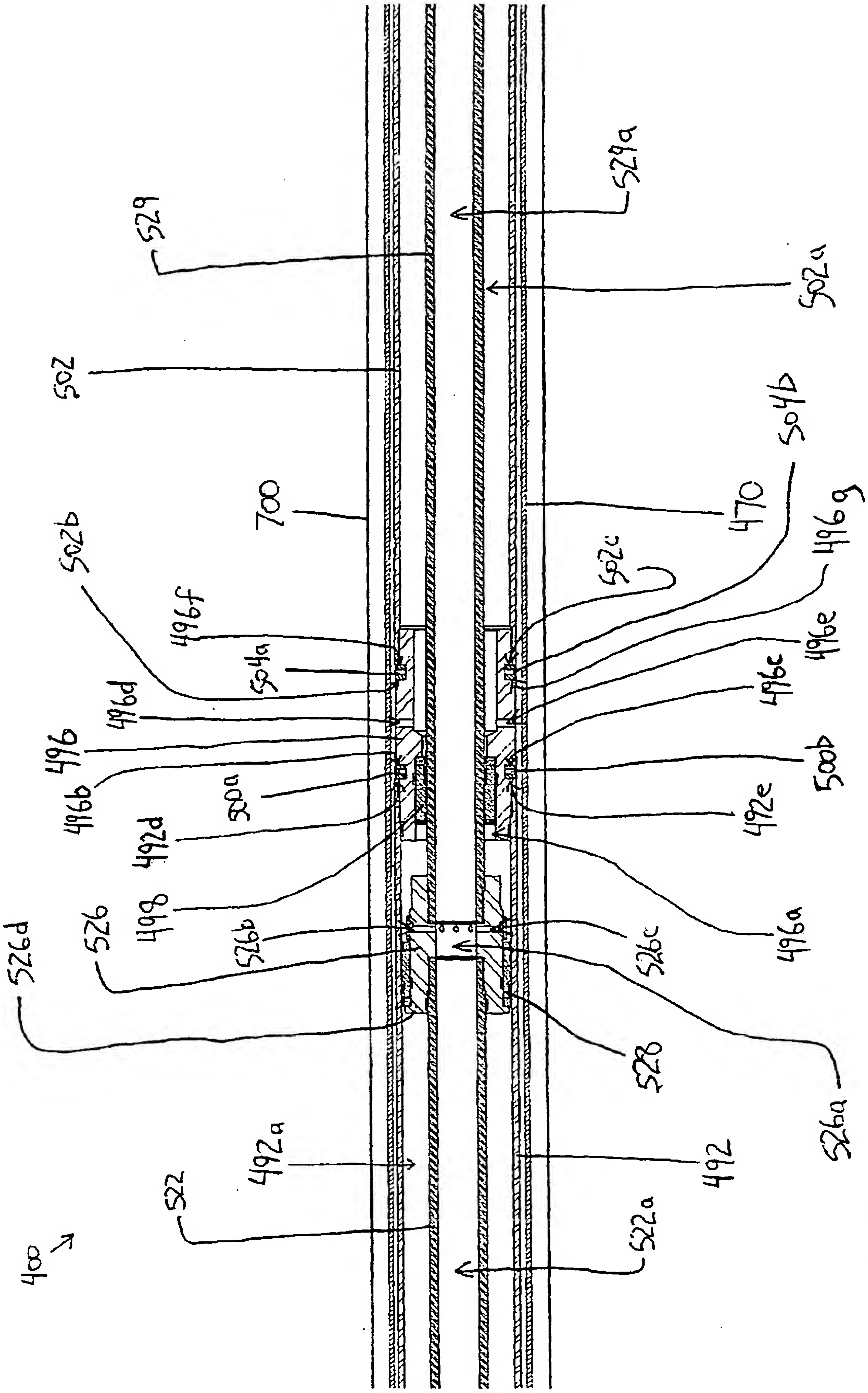

400
522
522a
492a
492
526d
526
526b
526c
526a
528
498
492d
492e
496a
500a
500b
496b
496
496d
496c
496e
496g
504a
496f
502b
502c
504b
700
470
502
502a
529
529a

Fig. 24f

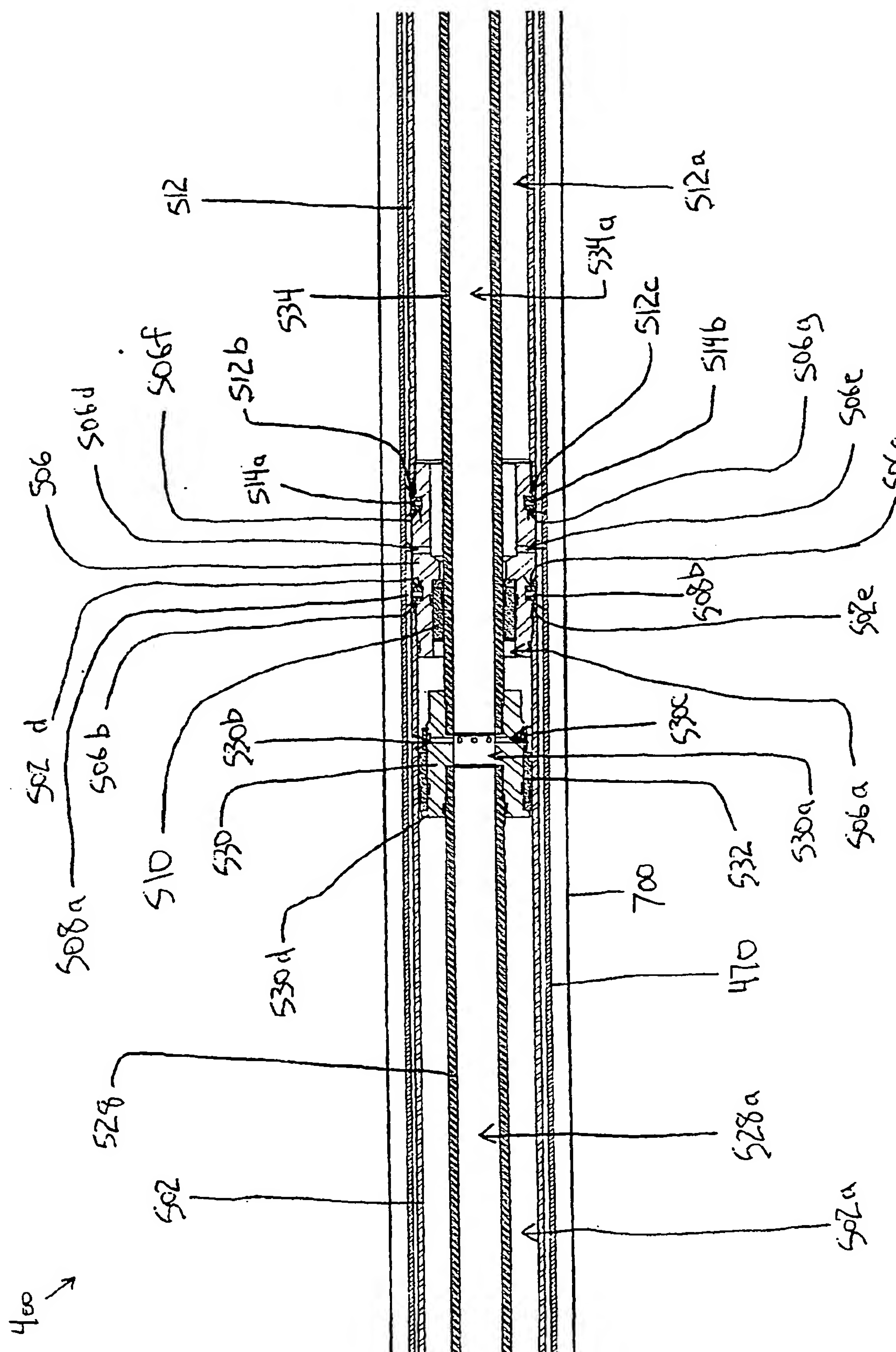
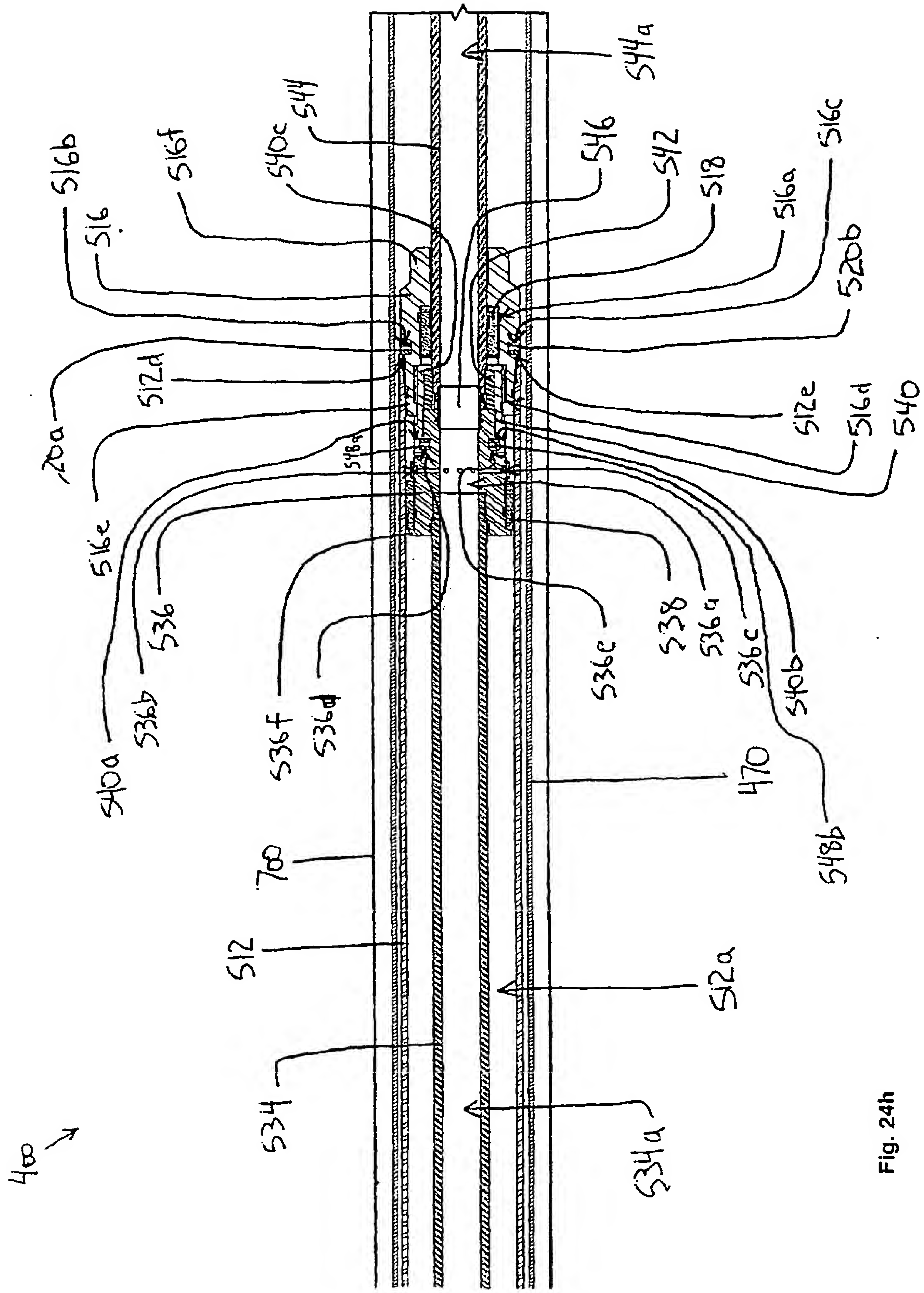

400
512
512a
534
534a
512c
512b
506f
506d
506
514a
514b
506g
506e
506c
508b
502e
502d
506b
510
530b
530c
530
532
530a
506a
508a
530d
700
470
528
528a
502
502a

Fig. 24g



400
534
534a
512
512a
700
470
536f
536d
536e
540a
536b
536
538
536a
536c
540b
548b
516e
548a
20a
512d
512e
516d
540
516b
516
516f
540c
544
546
542
518
516a
516c
520b
544a

Fig. 24h

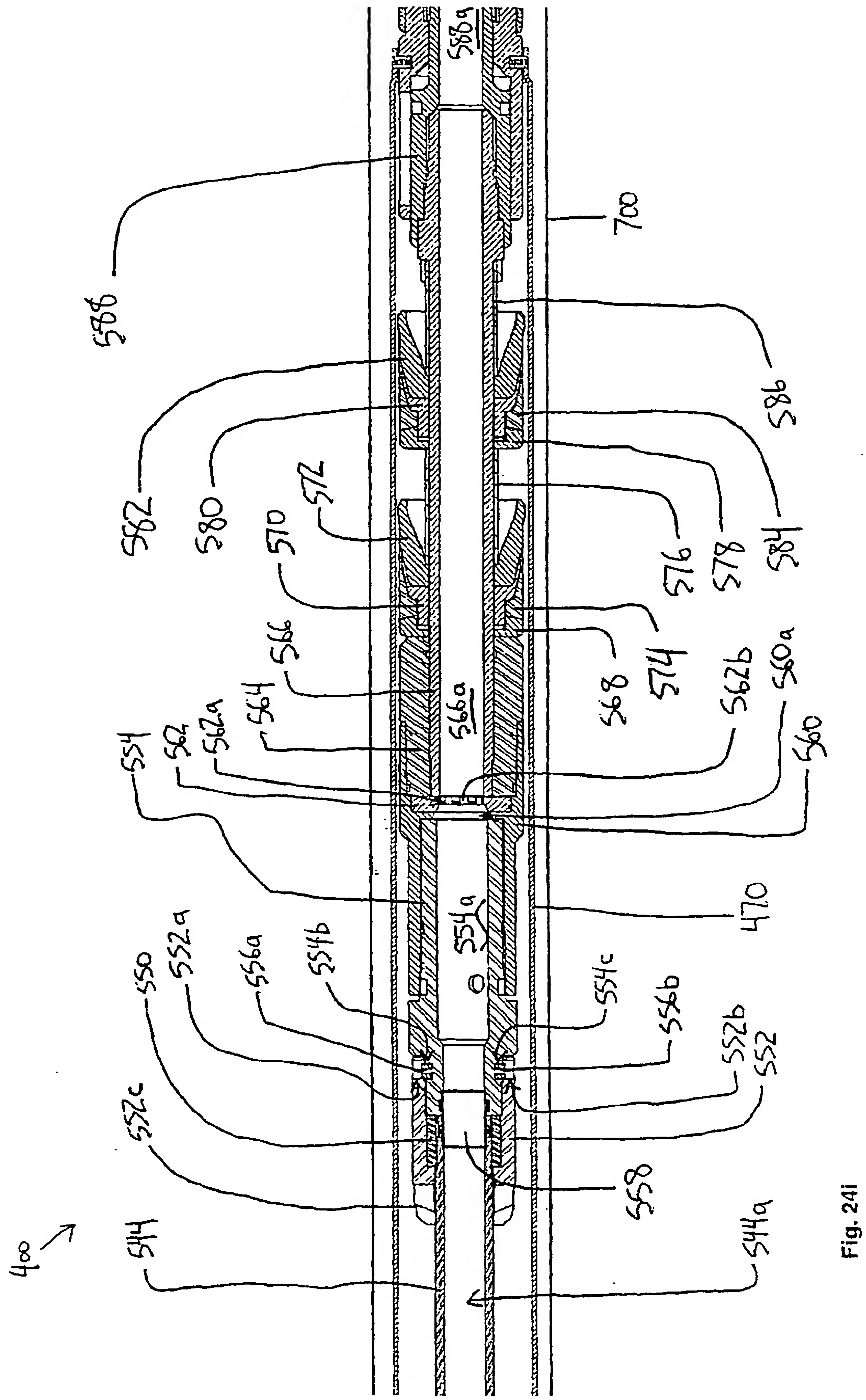

400
544
544a
552c
550
552a
556a
554b
554
562
562a
564
566
570
572
580
582
588
588a
700
586
584
578
576
574
568
562b
560a
560
566a
554a
470
554c
556b
552b
552
558

Fig. 24i

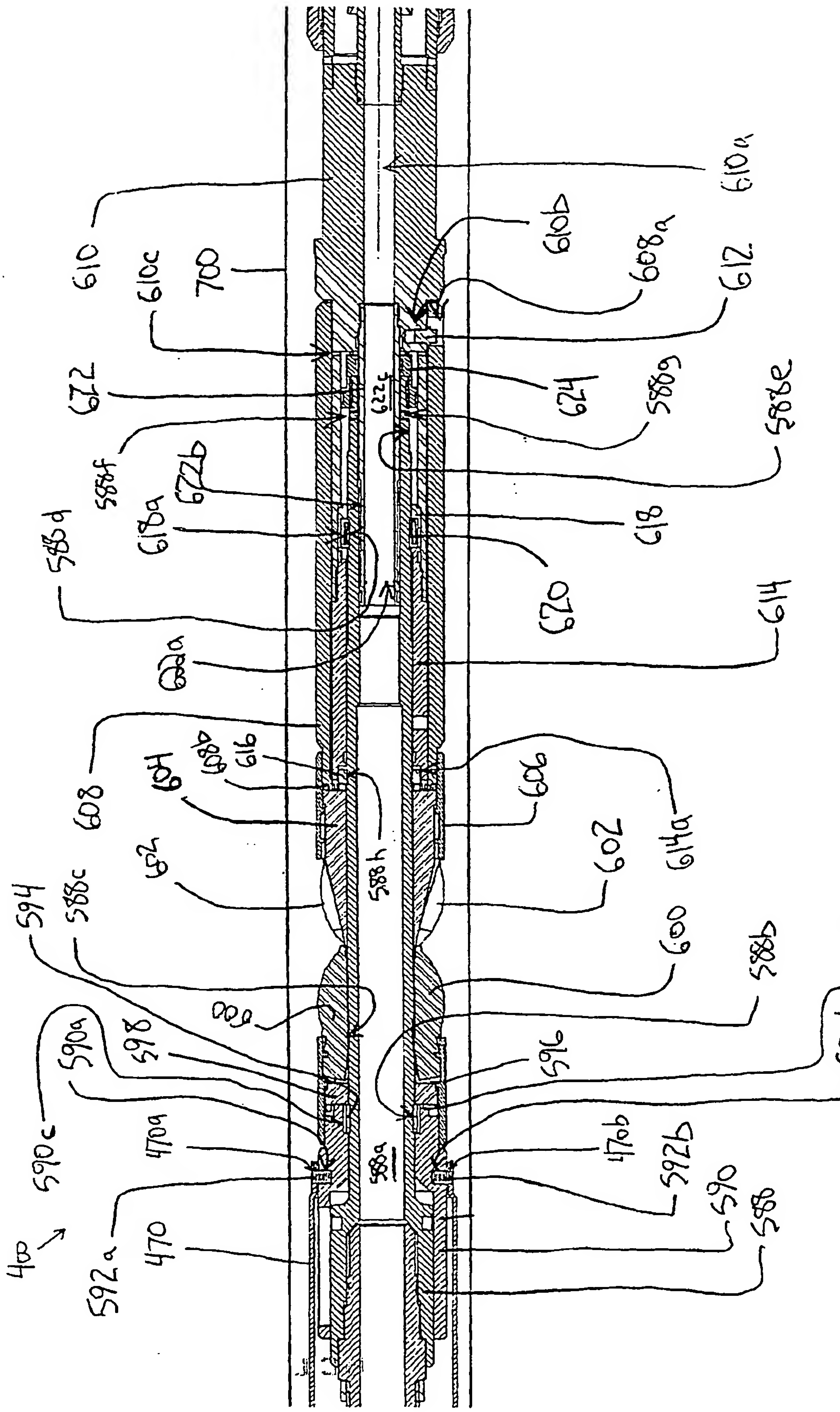
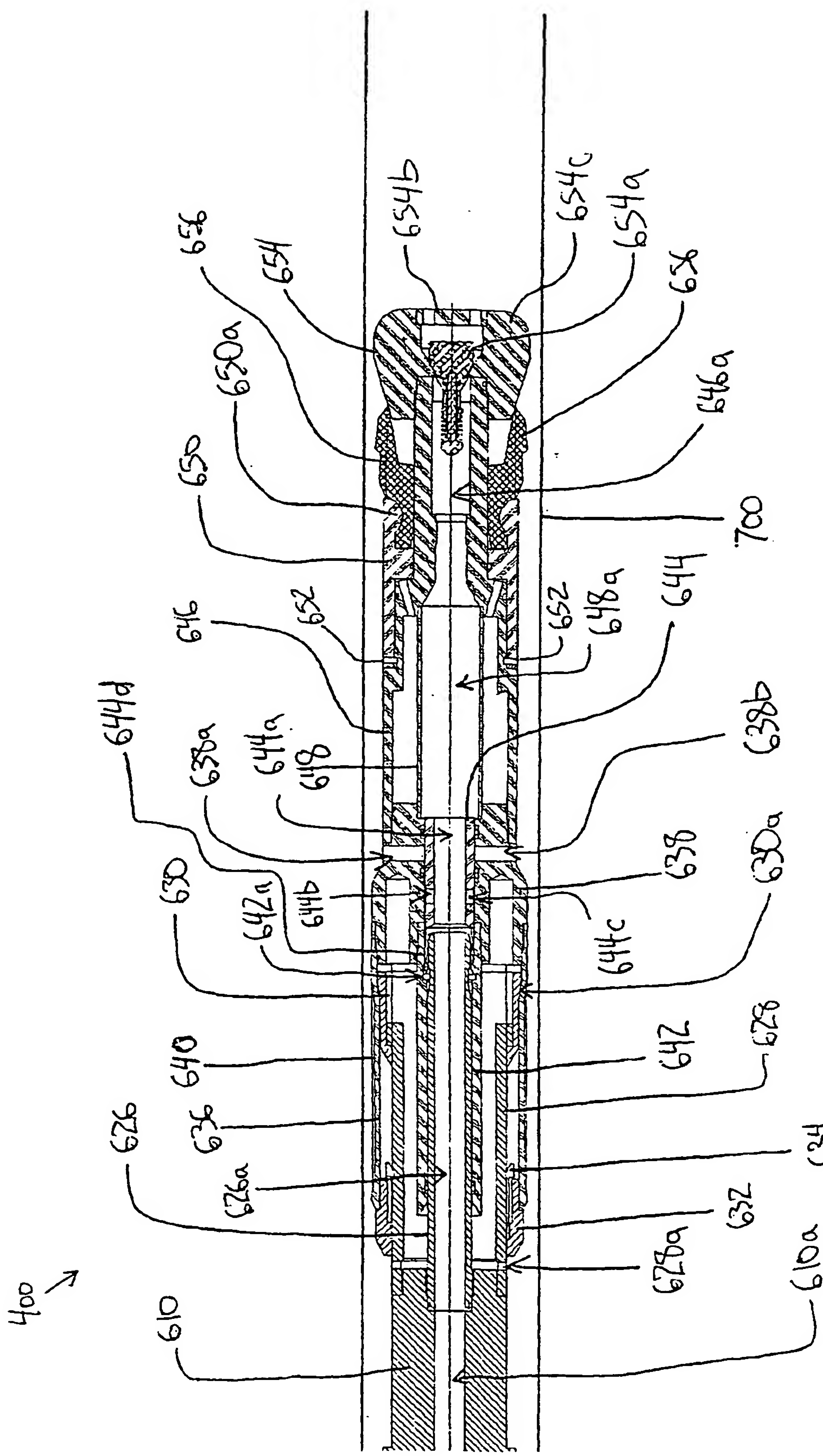

400
470
592a
590c
470a
590a
598
594
588c
600
602
608
610
610c
700
622
588f
588d
618a
622b
616
588h
610a
610b
608a
612
624
588g
588e
618
620
614
606
614a
596
590b
590d
588b
470b
592b
590
588

Fig. 24j



400
610
610a
626
626a
628
628a
630
630a
632
634
636
638
638a
638b
640
642
642a
644
644a
644b
644c
644d
646
646a
648a
650
650a
652
654
654a
654b
654c
700

Fig. 24k

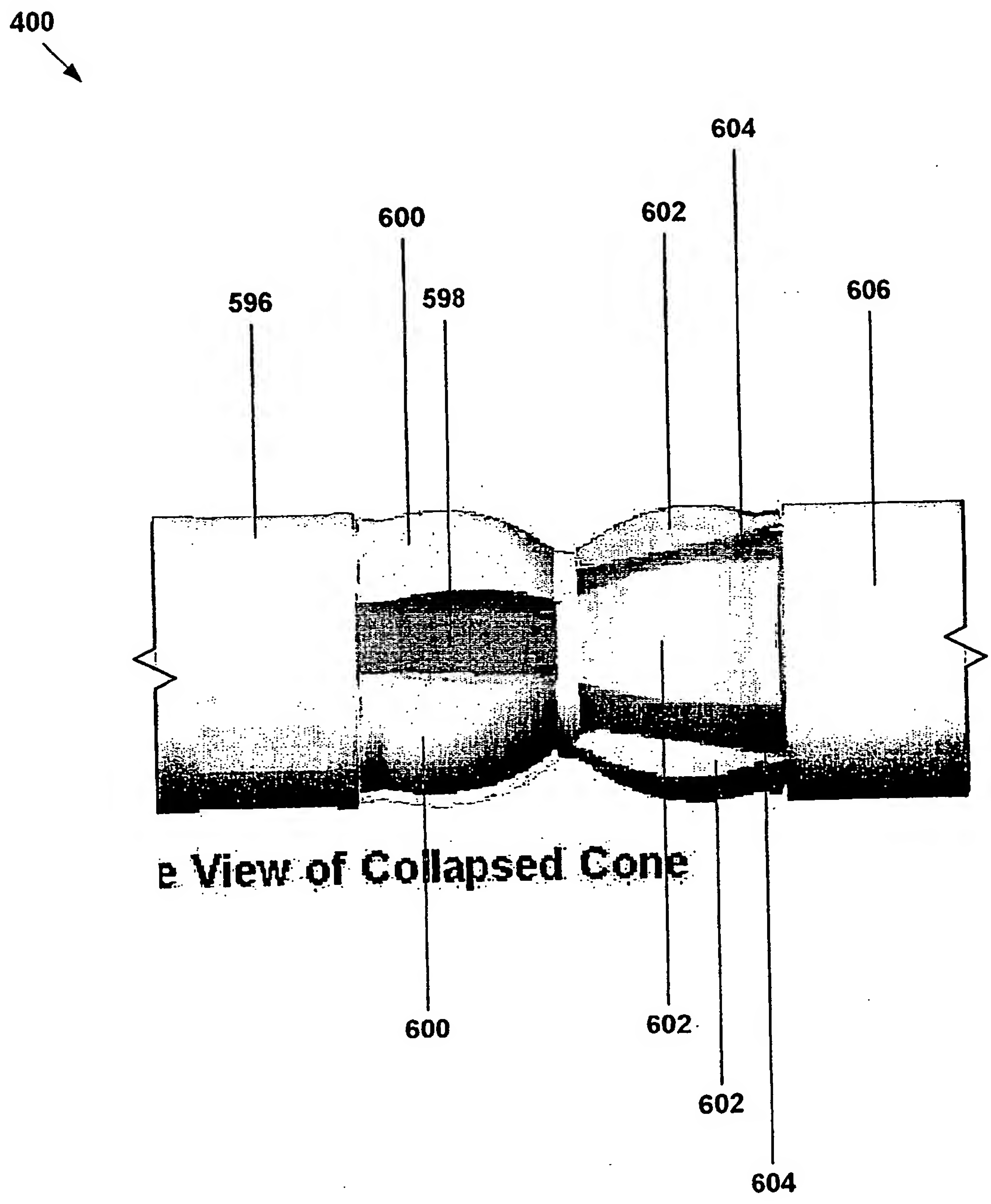
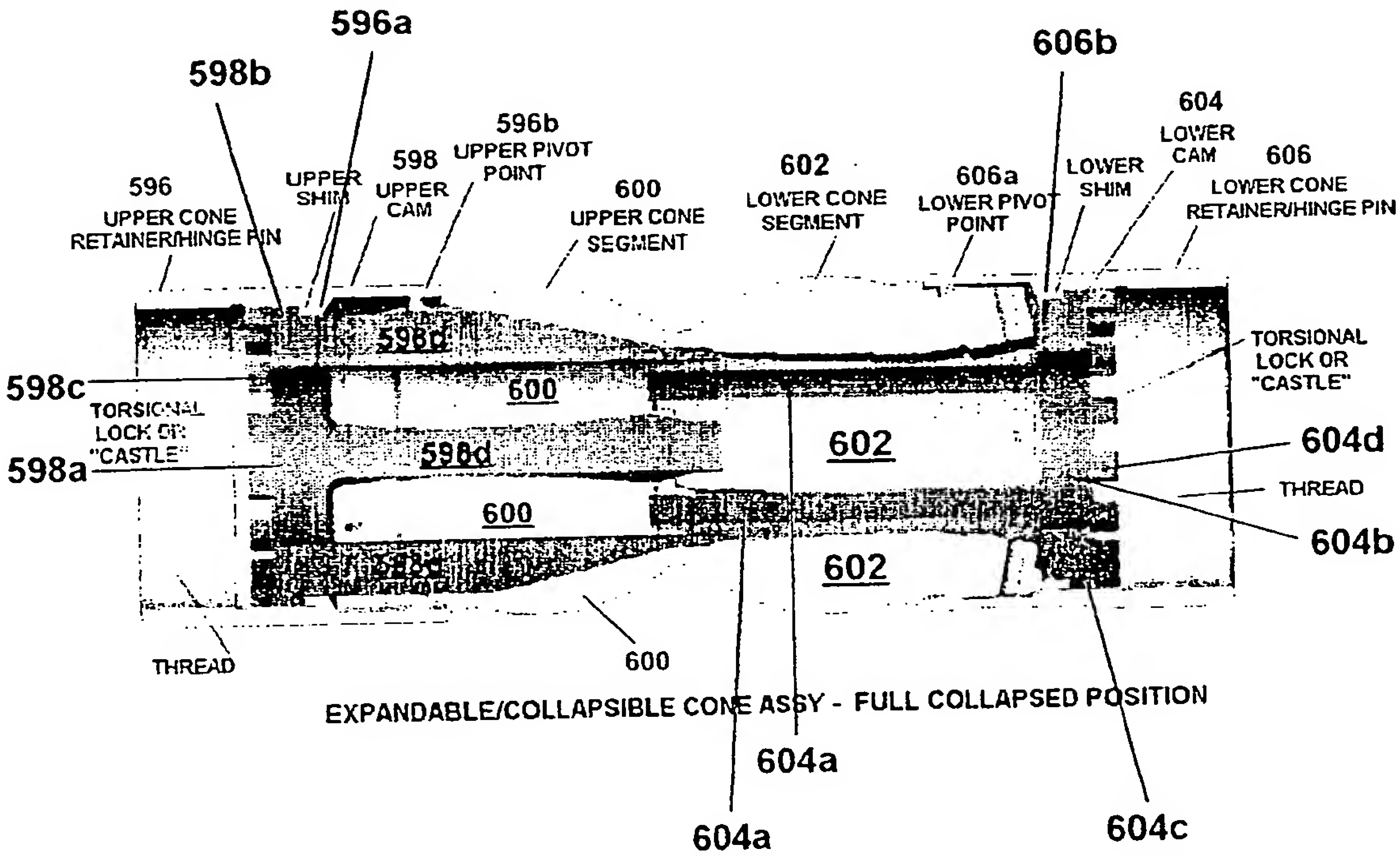

400
604
600
602
596
598
606
e View of Collapsed Cone
600
602
602
604

FIG. 25a

400



EXPANDABLE/COLLAPSIBLE CONE ASSY - FULL COLLAPSED POSITION

FIG. 25b

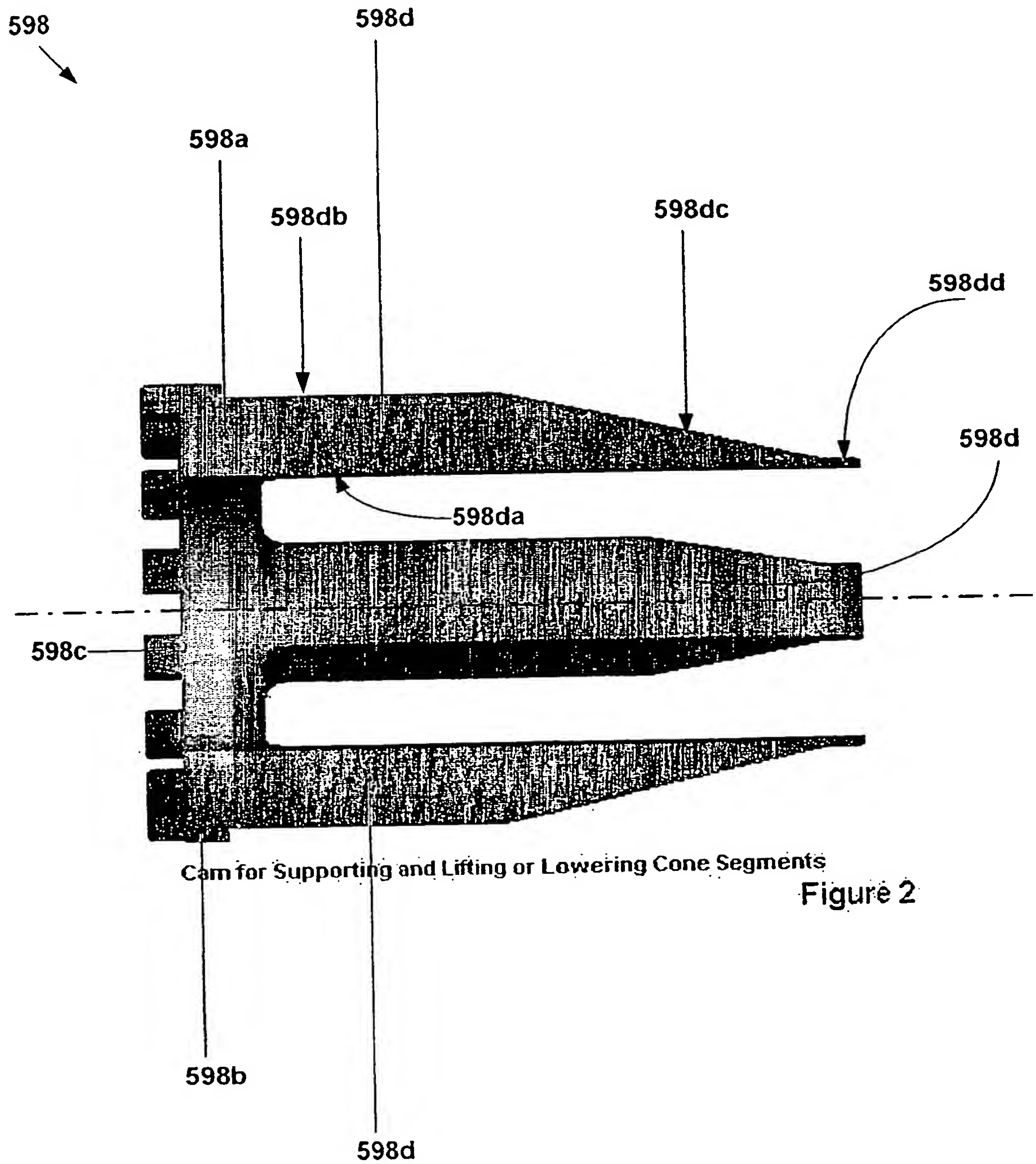

598
598d
598a
598db
598dc
598dd
598d
598da
598c
Cam for Supporting and Lifting or Lowering Cone Segments
Figure 2
598b
598d

FIG. 25c

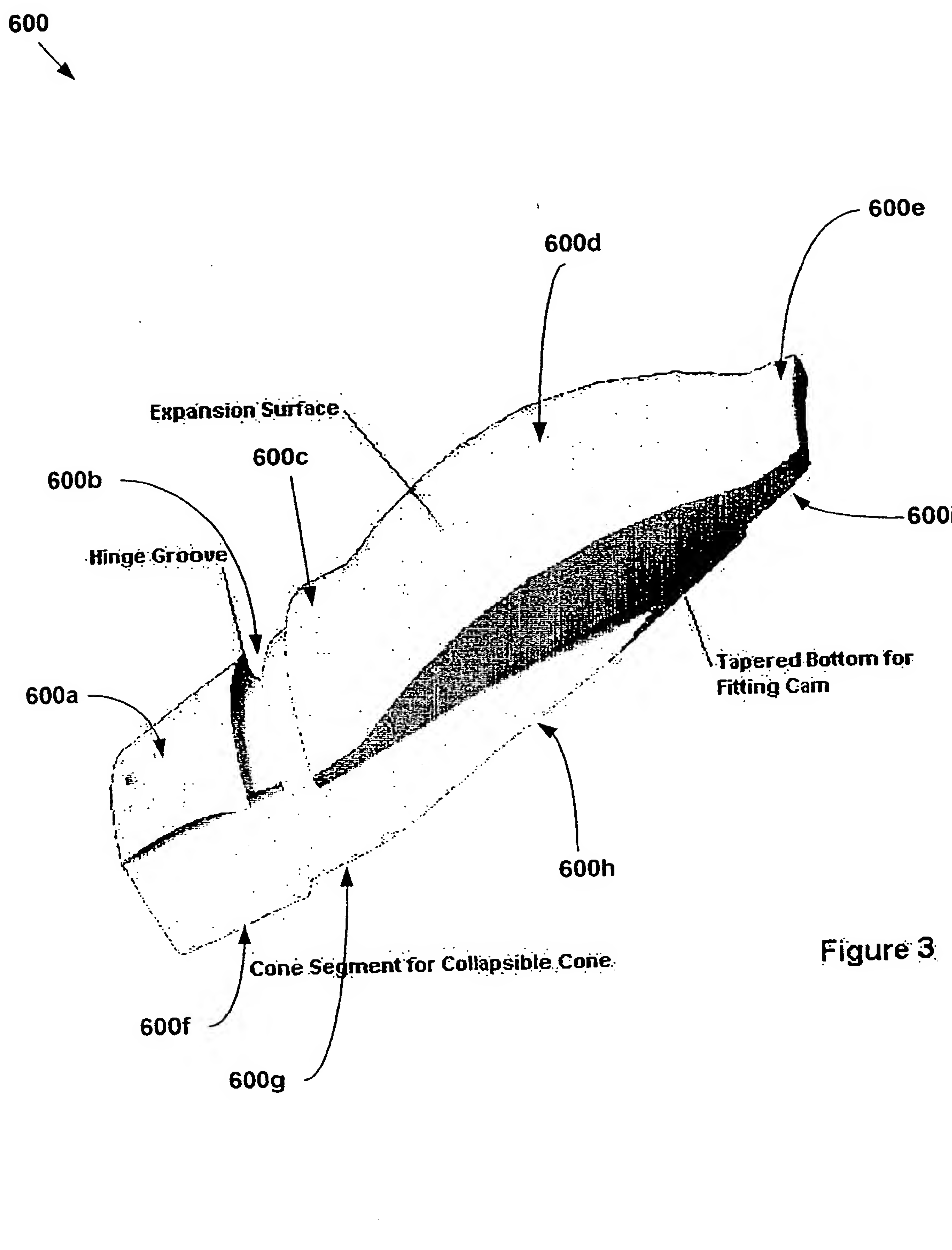

600
600e
600d
Expansion Surface
600c
600b
600i
Hinge Groove
Tapered Bottom for
Fitting Cam
600a
600h
Cone Segment for Collapsible Cone
600f
600g
Figure 3

FIG. 25d

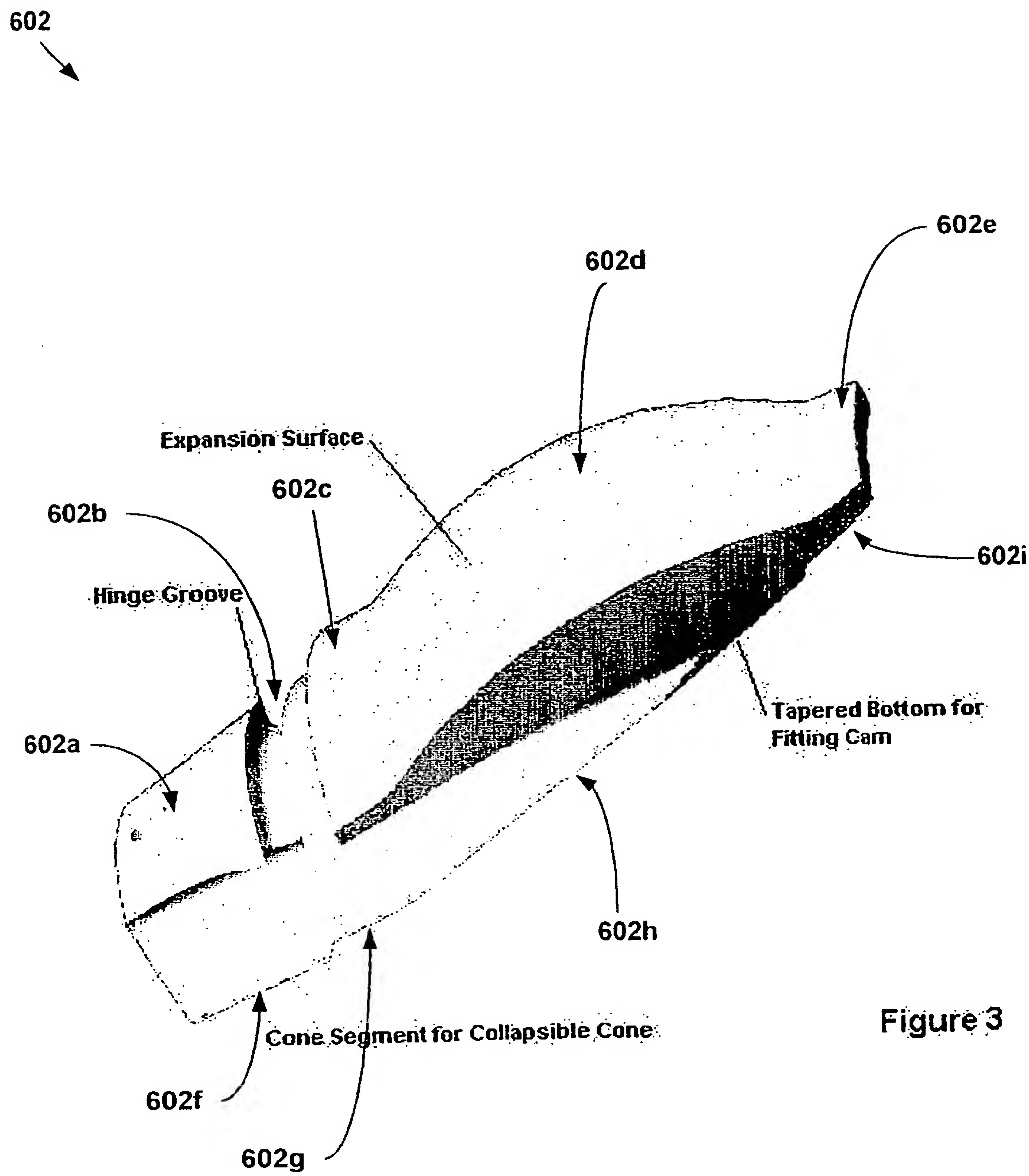

602
602e
602d
Expansion Surface
602c
602b
602i
Hinge Groove
Tapered Bottom for Fitting Cam
602a
602h
Figure 3
Cone Segment for Collapsible Cone
602f
602g

FIG. 25e

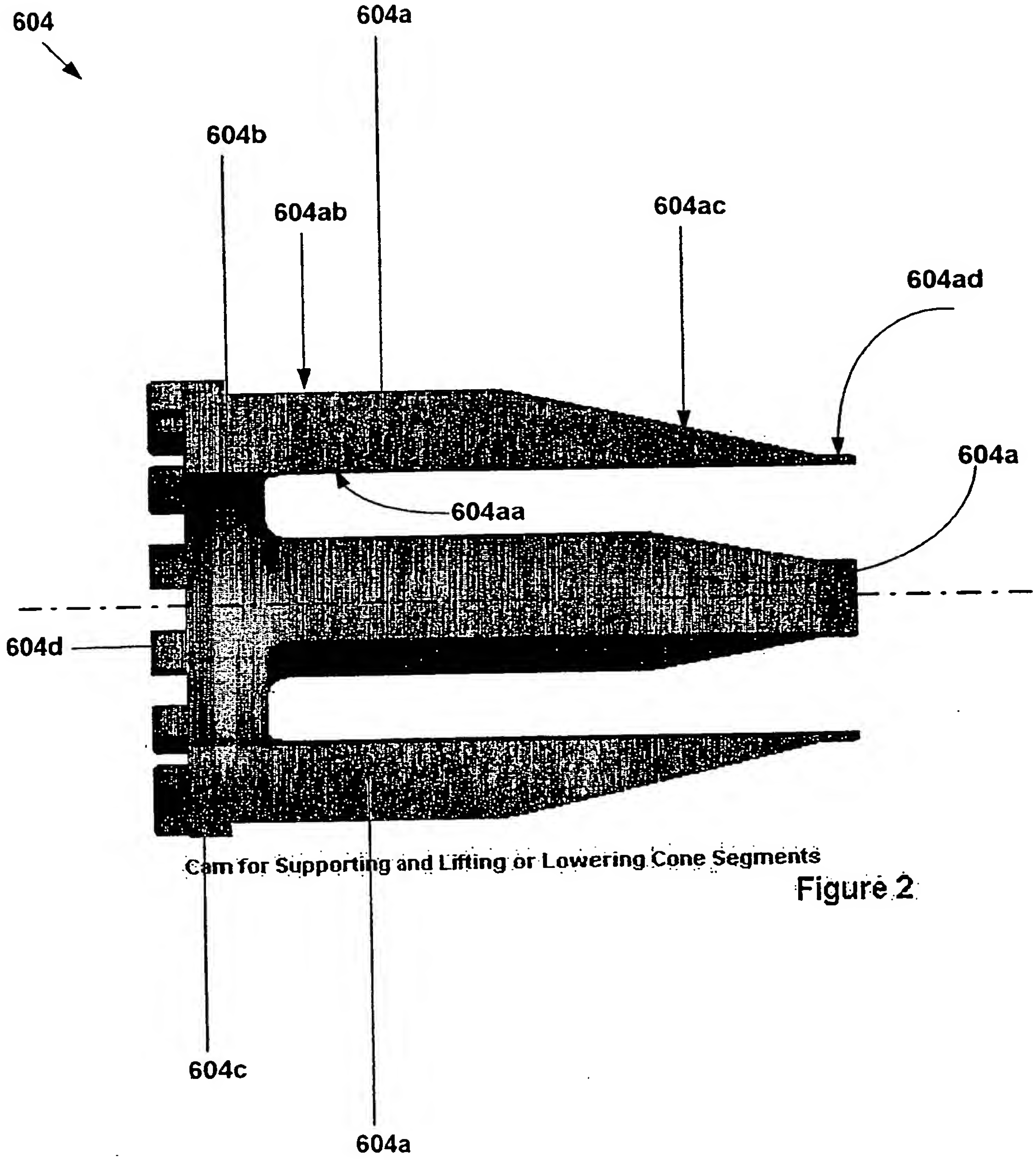
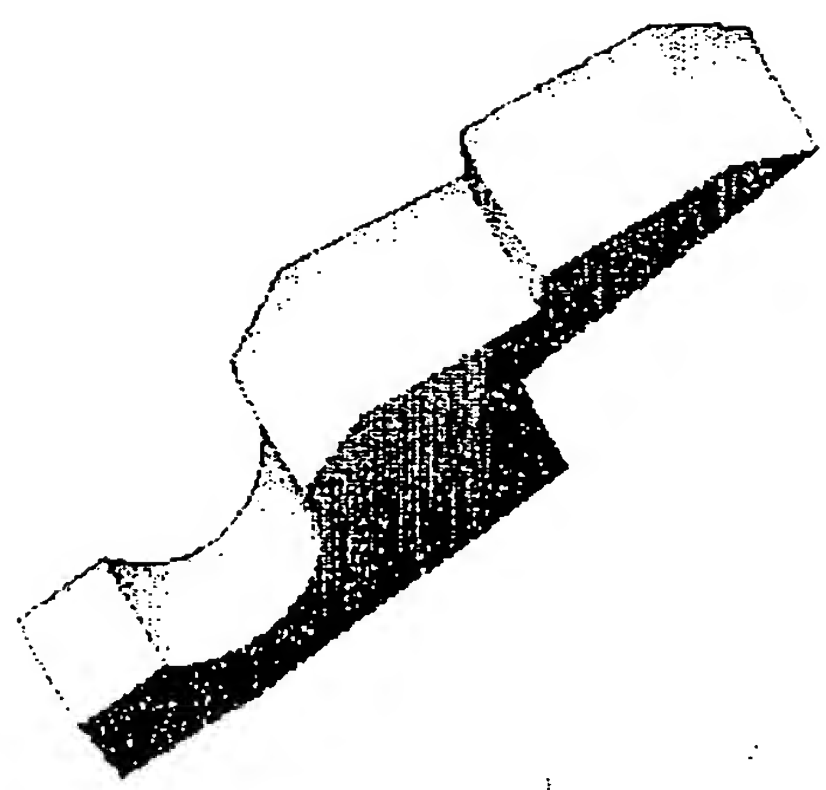

604
604a
604b
604ab
604ac
604ad
604a
604aa
604d
Cam for Supporting and Lifting or Lowering Cone Segments
Figure 2
604c
604a

FIG. 25f

656



Float Shoe Locking Dog

Fig. 25g

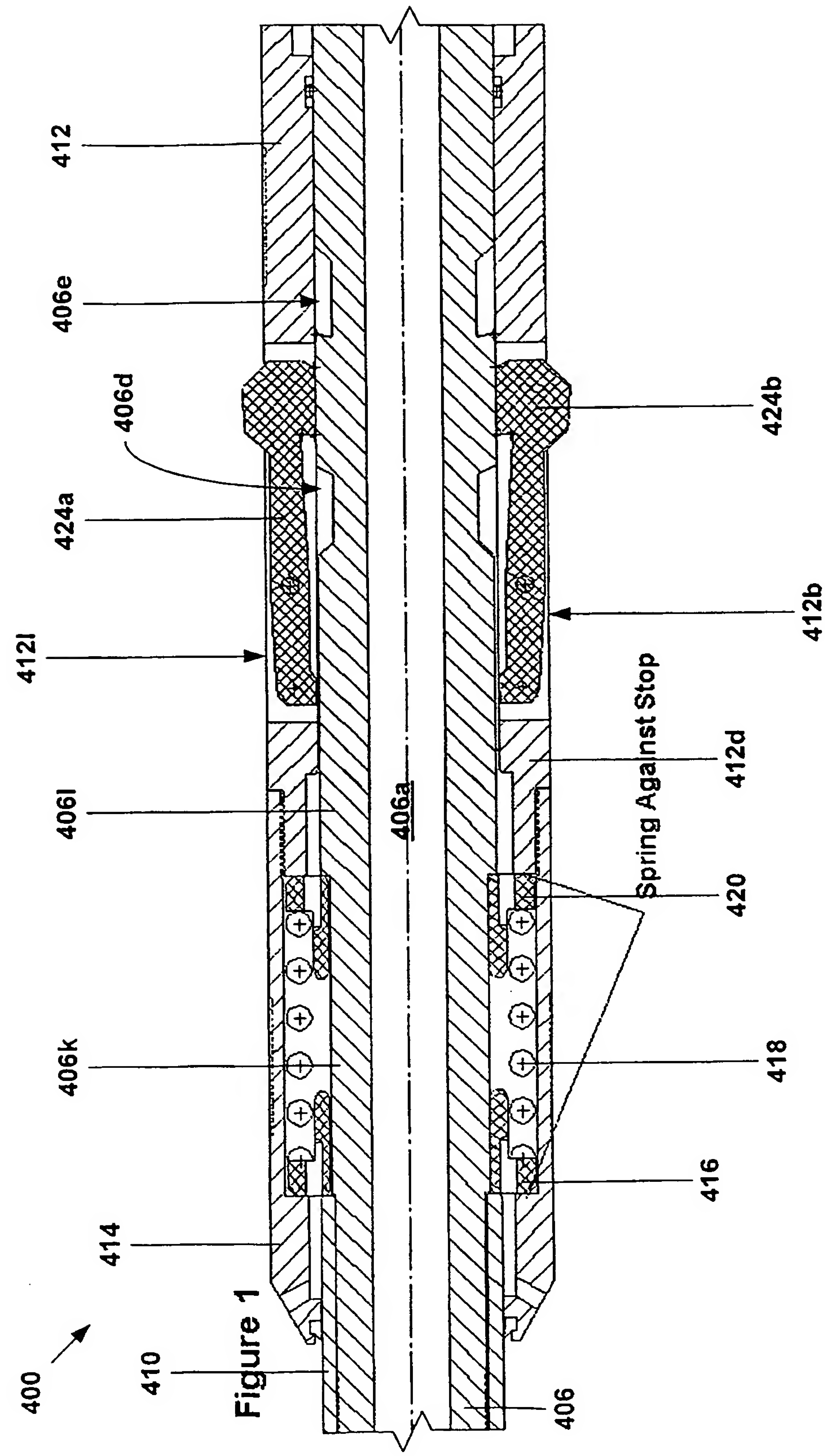

412
406e
406d
424a
412l
406l
406k
414
400
410
Figure 1
406a
424b
412b
Spring Against Stop
412d
420
418
416
406

Fig. 25h

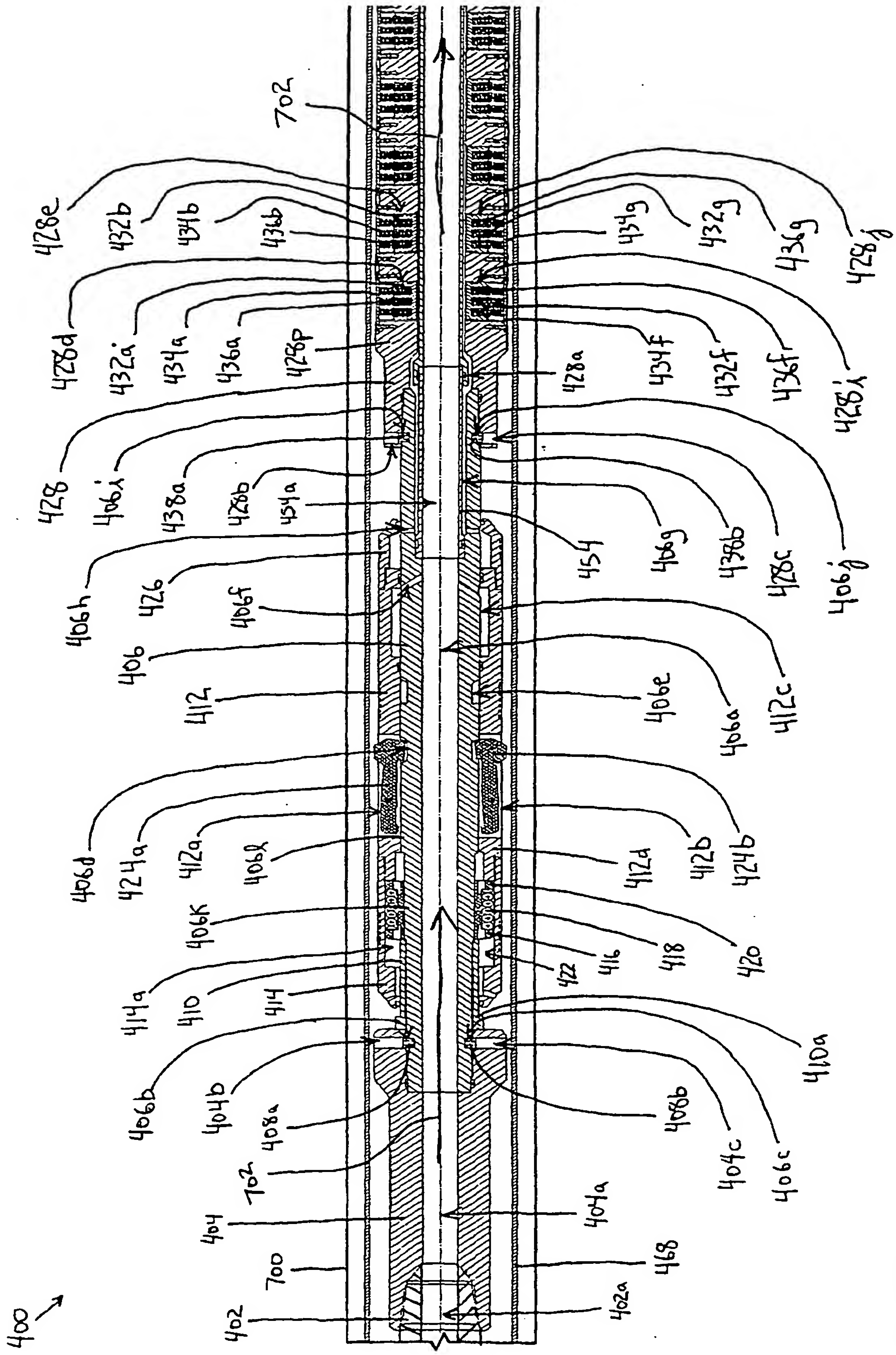

400
402
402a
404
404a
404b
404c
406
406a
406b
406c
406d
406e
406f
406g
406h
406i
406j
406k
406l
408a
408b
410
410a
412
412a
412b
412c
412d
414
414a
416
418
420
422
424a
424b
426
428
428a
428b
428c
428d
428e
428i
428j
428p
432a
432b
432f
432g
434a
434b
434f
434g
436a
436b
436f
436g
438a
438b
454
454a
468
700
702

Fig. 26a

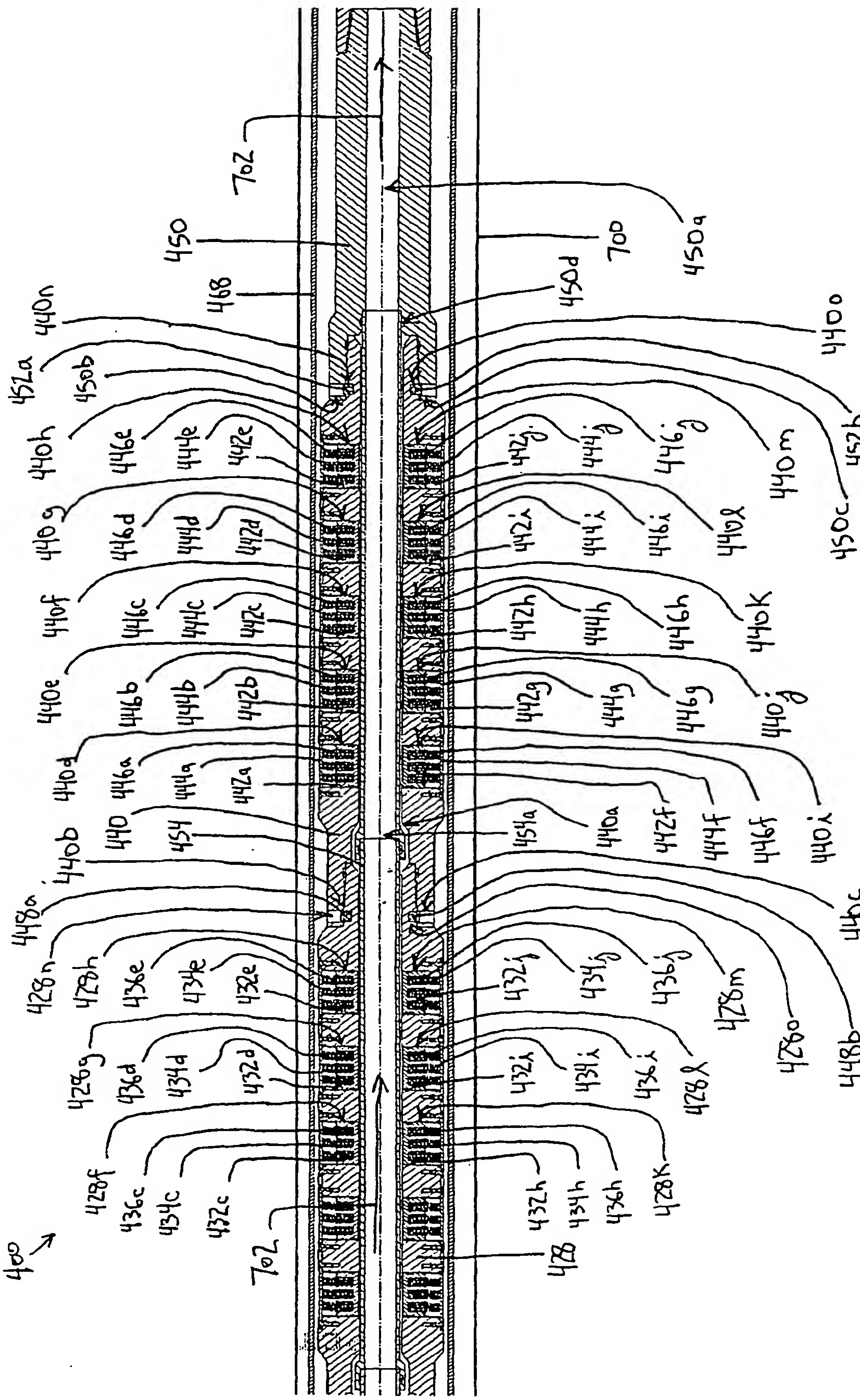


Fig. 26b

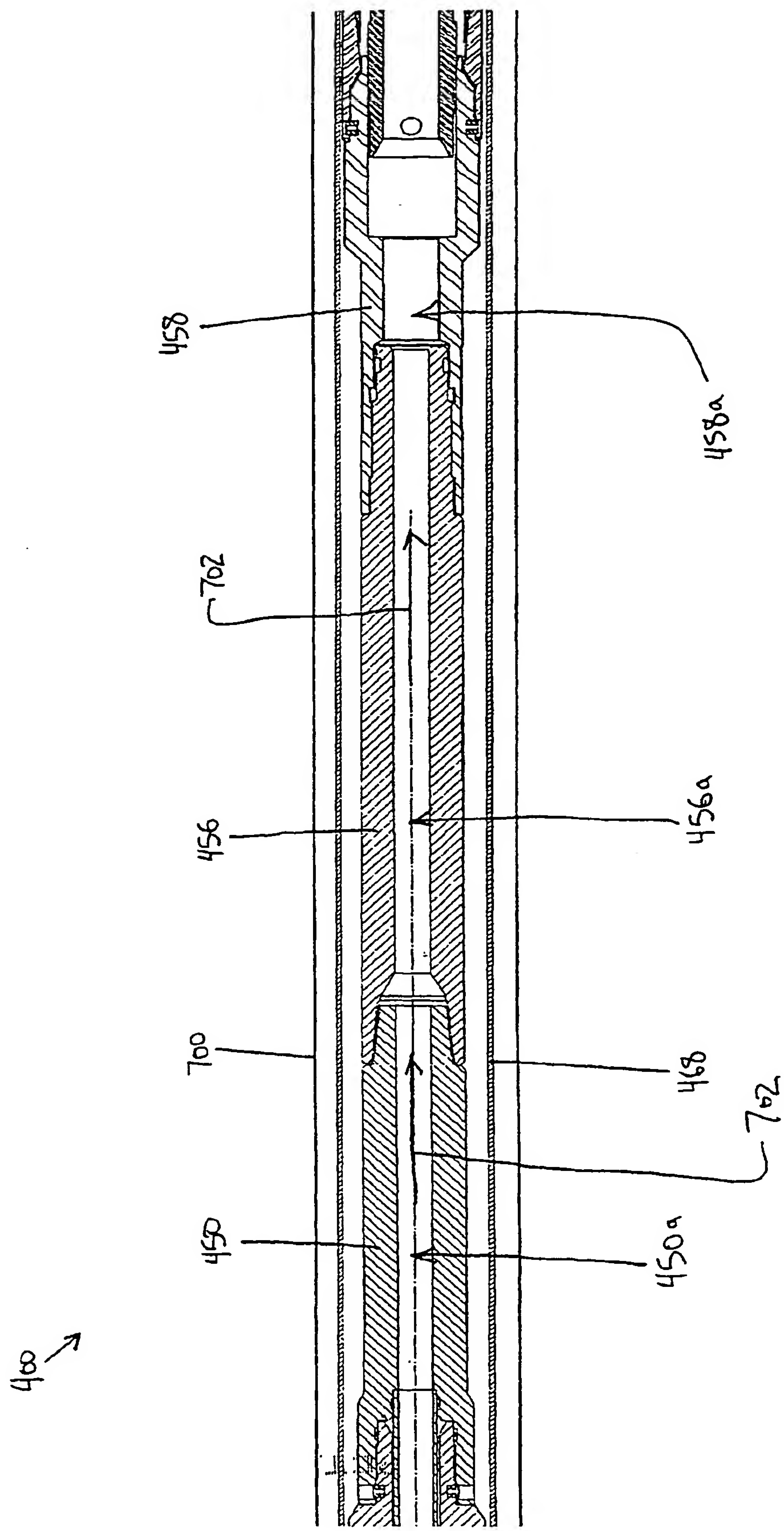


Fig. 26c

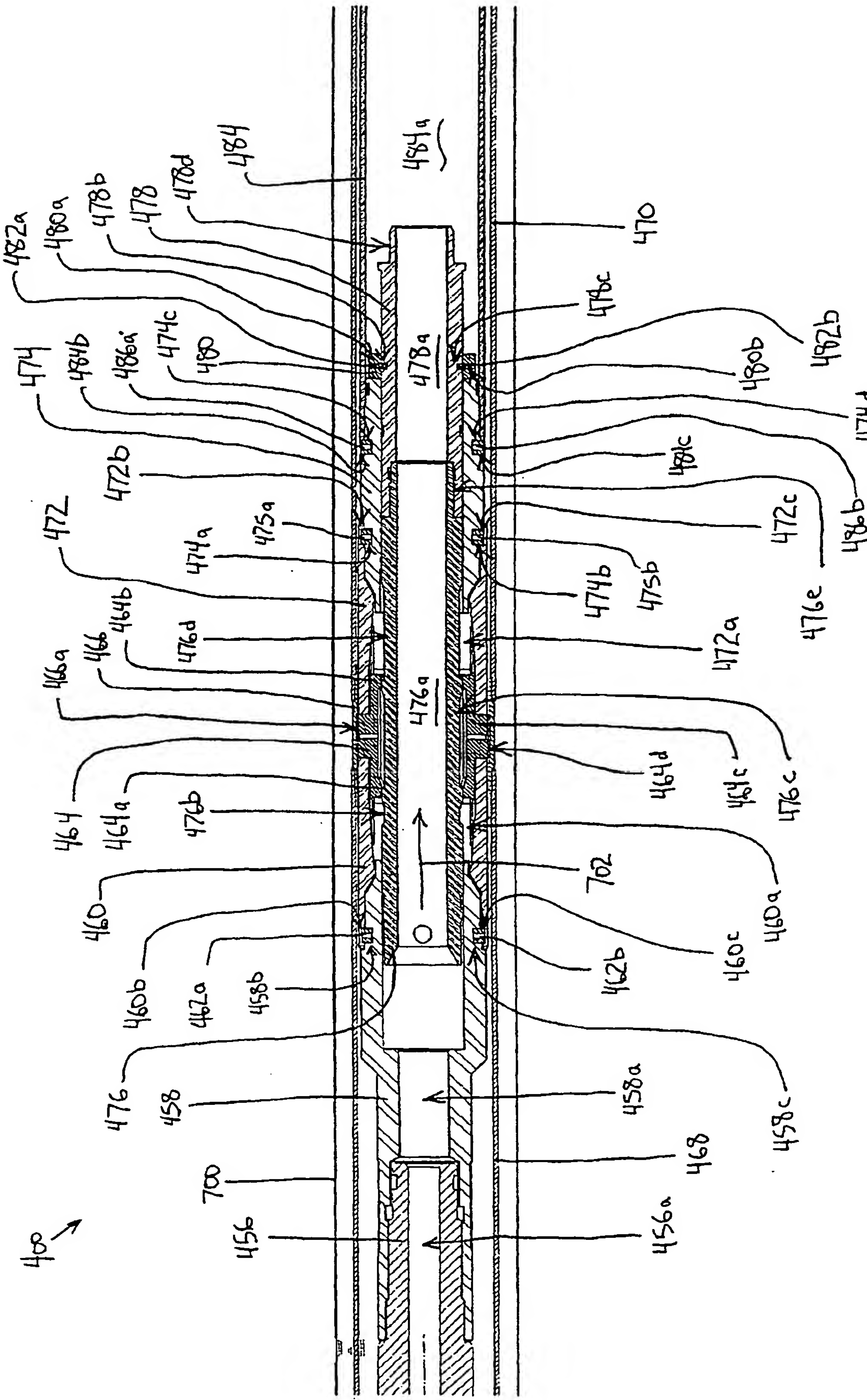

484
484a
470
478d
478
478b
480a
482a
478c
478a
482b
480b
474d
474
484b
486a'
474c
480
481c
486b
472b
472c
472
475a
474a
474b
475b
476e
476d
472a
466a
466
464b
476a
464d
464c
476c
464
464a
476b
702
460a
460
460b
462a
458b
462b
460c
476
458
458a
458c
468
700
456
456a

Fig. 26d

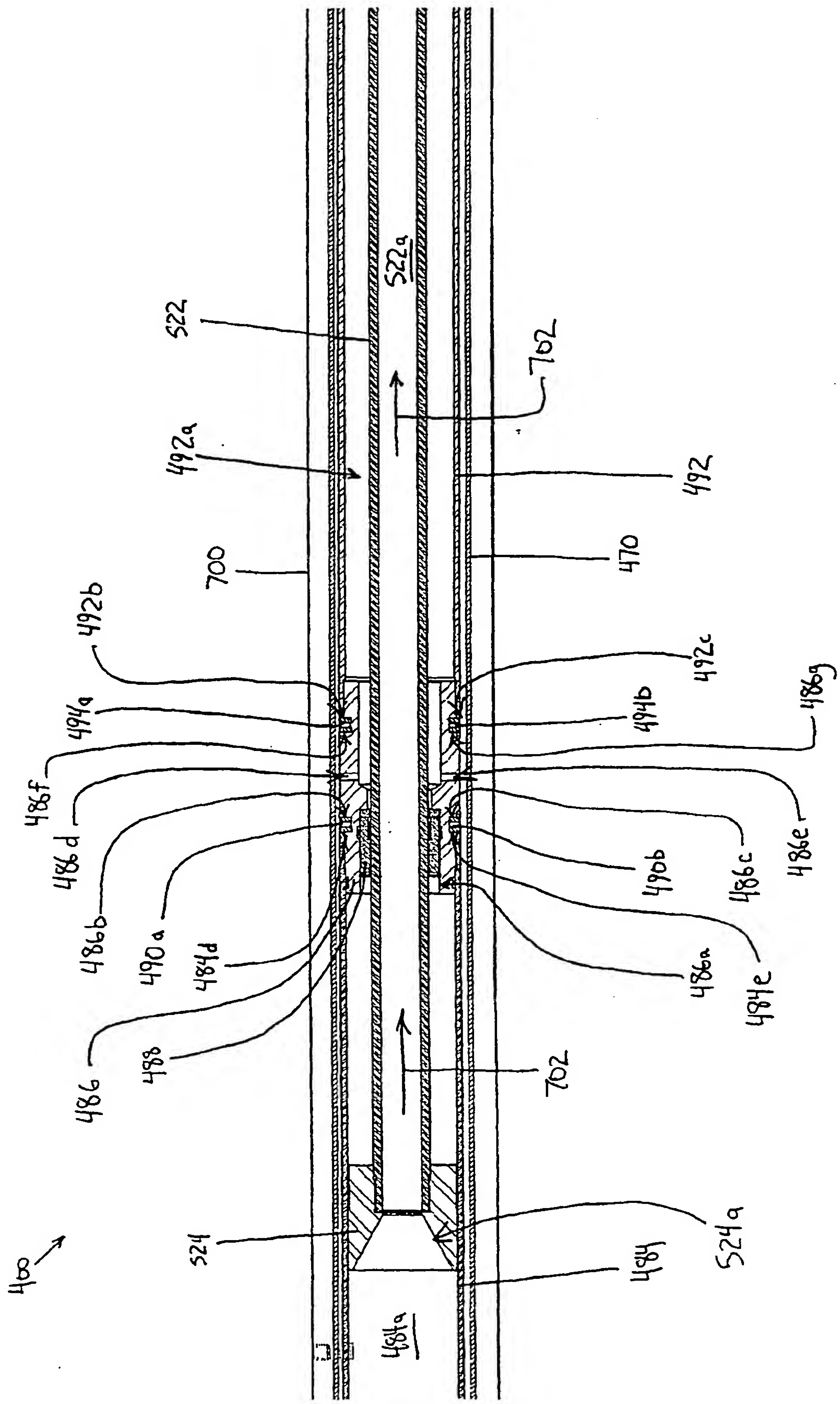

468
522
522a
702
492a
492
700
470
492b
492c
486g
494a
494b
486f
486d
486e
486c
490b
486b
490a
484d
486a
484e
486
488
702
524
524a
484
484a

Fig. 26e

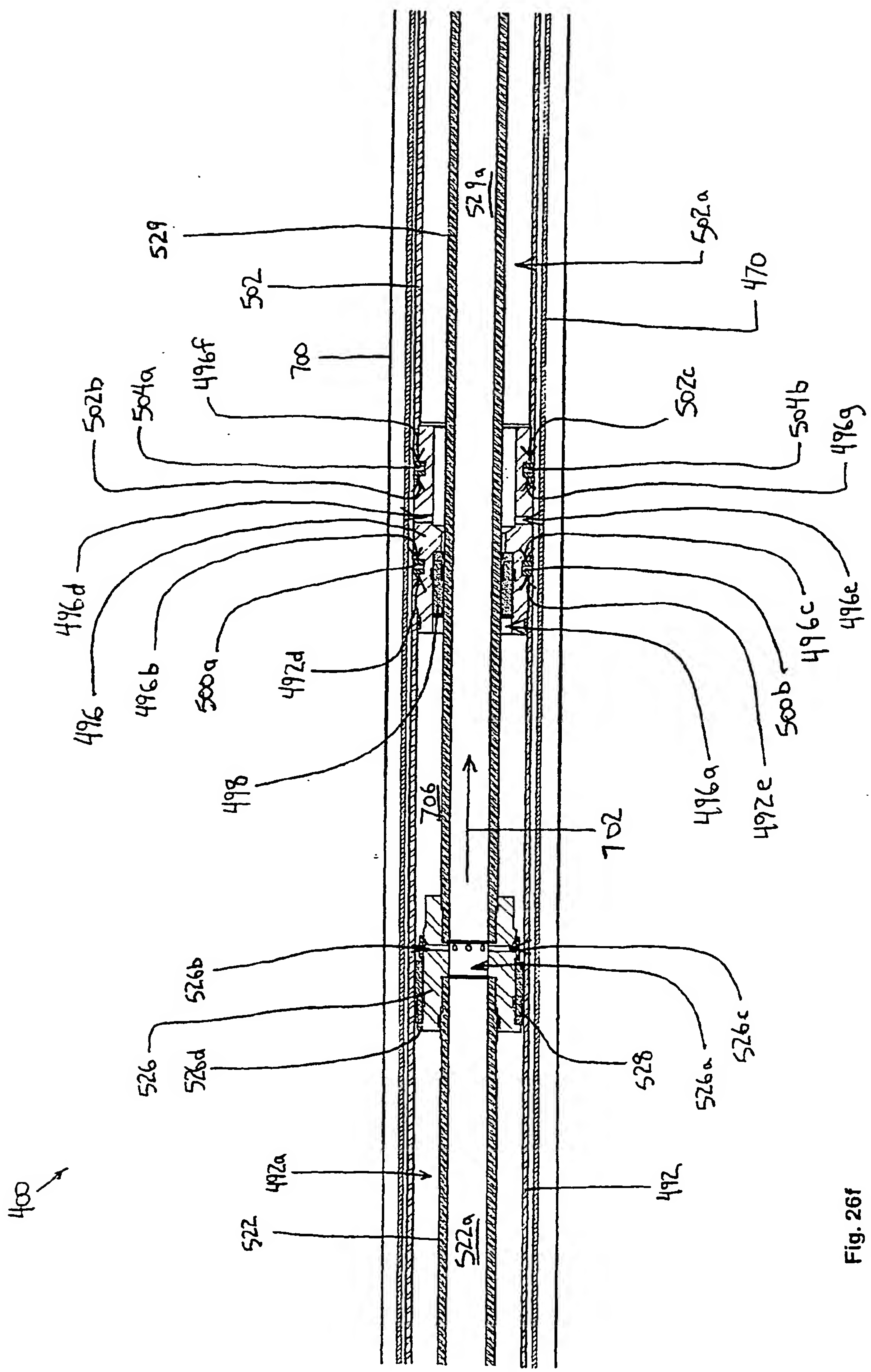

400
529
529a
502
502a
470
700
496f
504a
502b
502c
504b
496g
496d
496b
500a
492d
496
498
706
702
496e
496c
500b
496a
492e
526b
526
526d
528
526a
526c
492a
522
522a
492

Fig. 26f

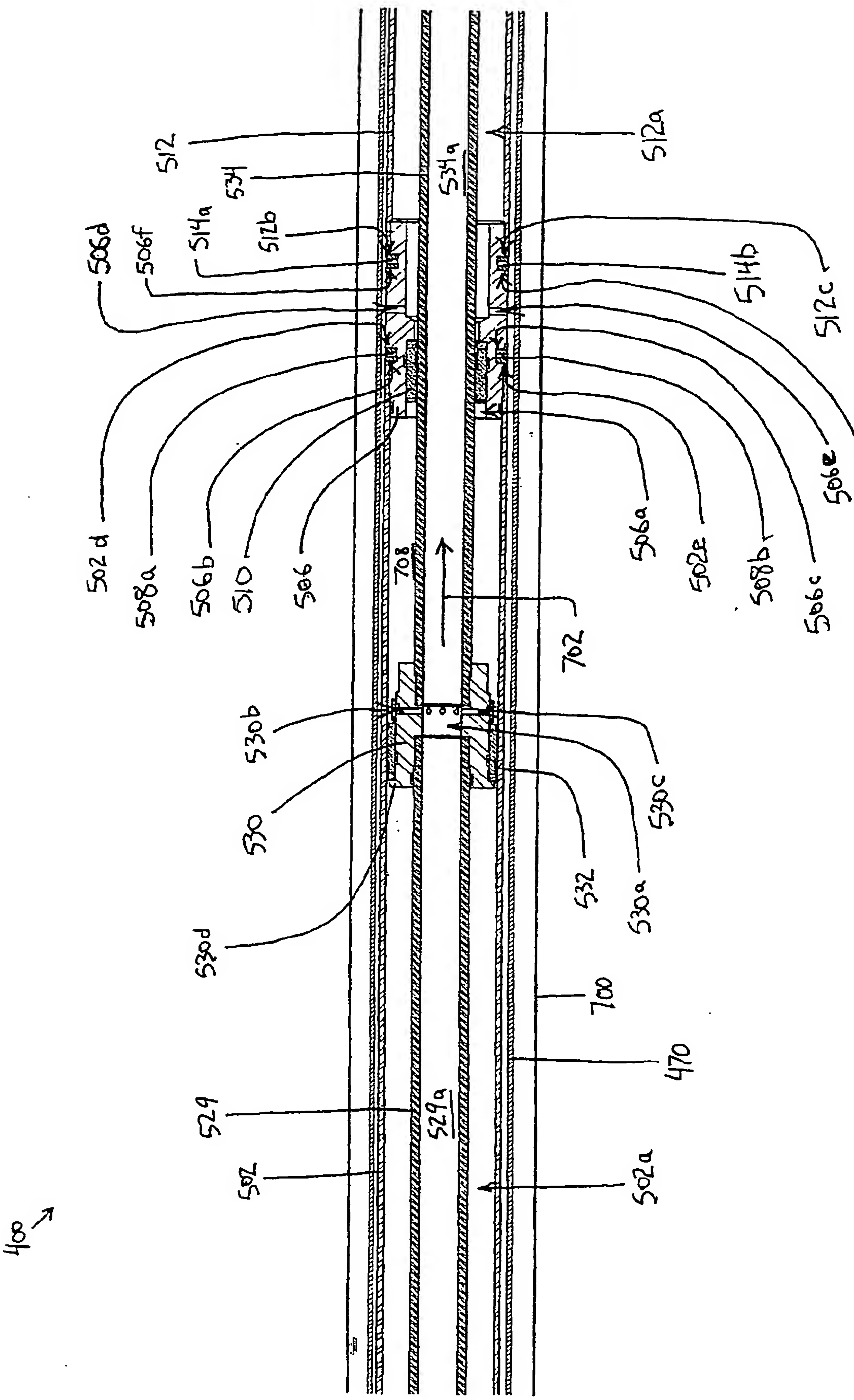

512
512a
534
534a
512b
514a
506f
506d
514b
512c
502d
508a
506b
510
506
708
506a
502e
508b
506e
506c
506g
702
530b
530
530c
532
530a
530d
700
470
529
529a
502
502a
400

Fig. 26g

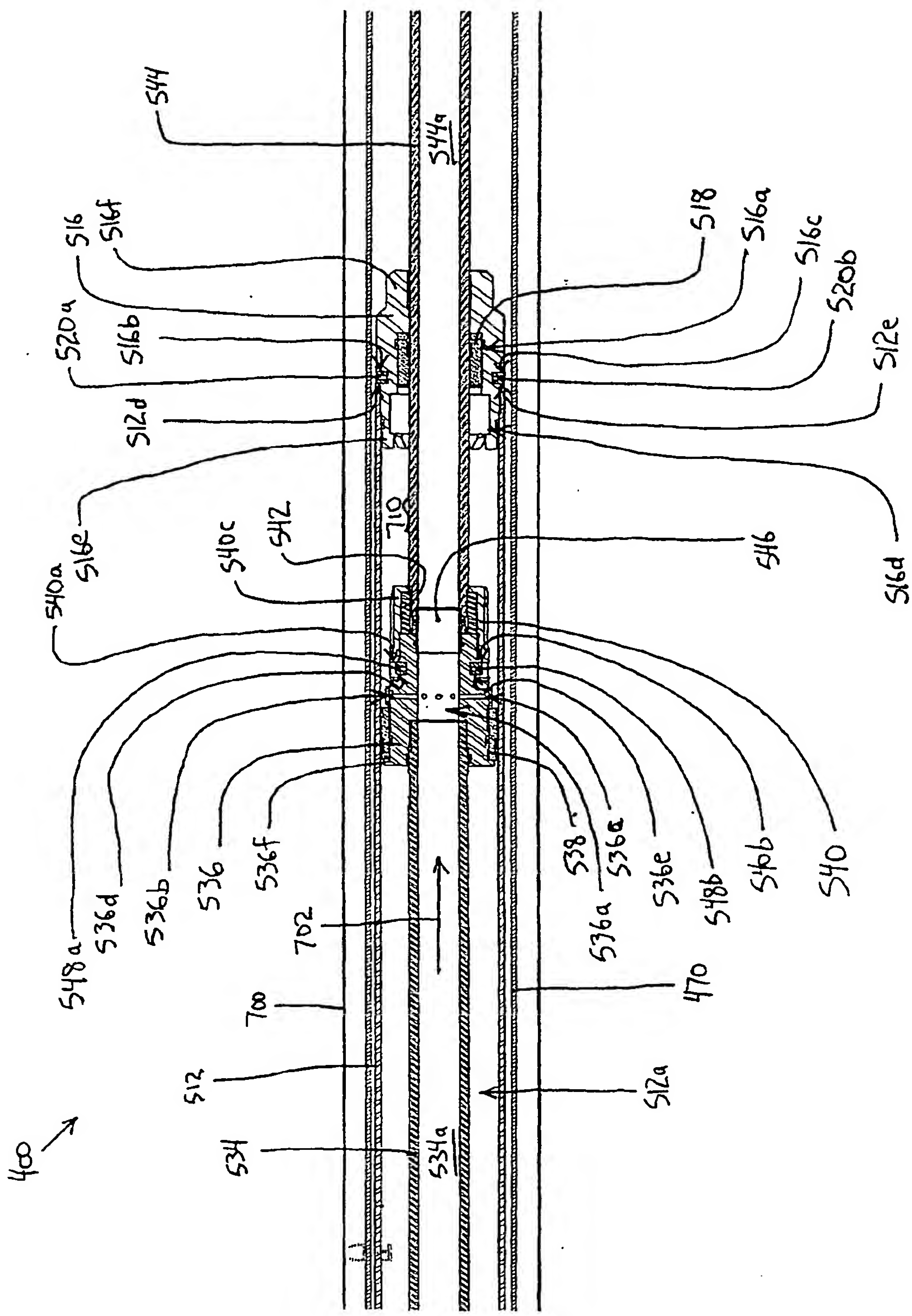

400
544
544a
516
516f
520a
516b
512d
518
516a
516c
520b
512e
516e
540a
540c
542
710
546
516d
548a
536d
536b
536
536f
538
536a
536e
548b
546b
540
702
700
512
470
512a
534
534a

Fig. 26h

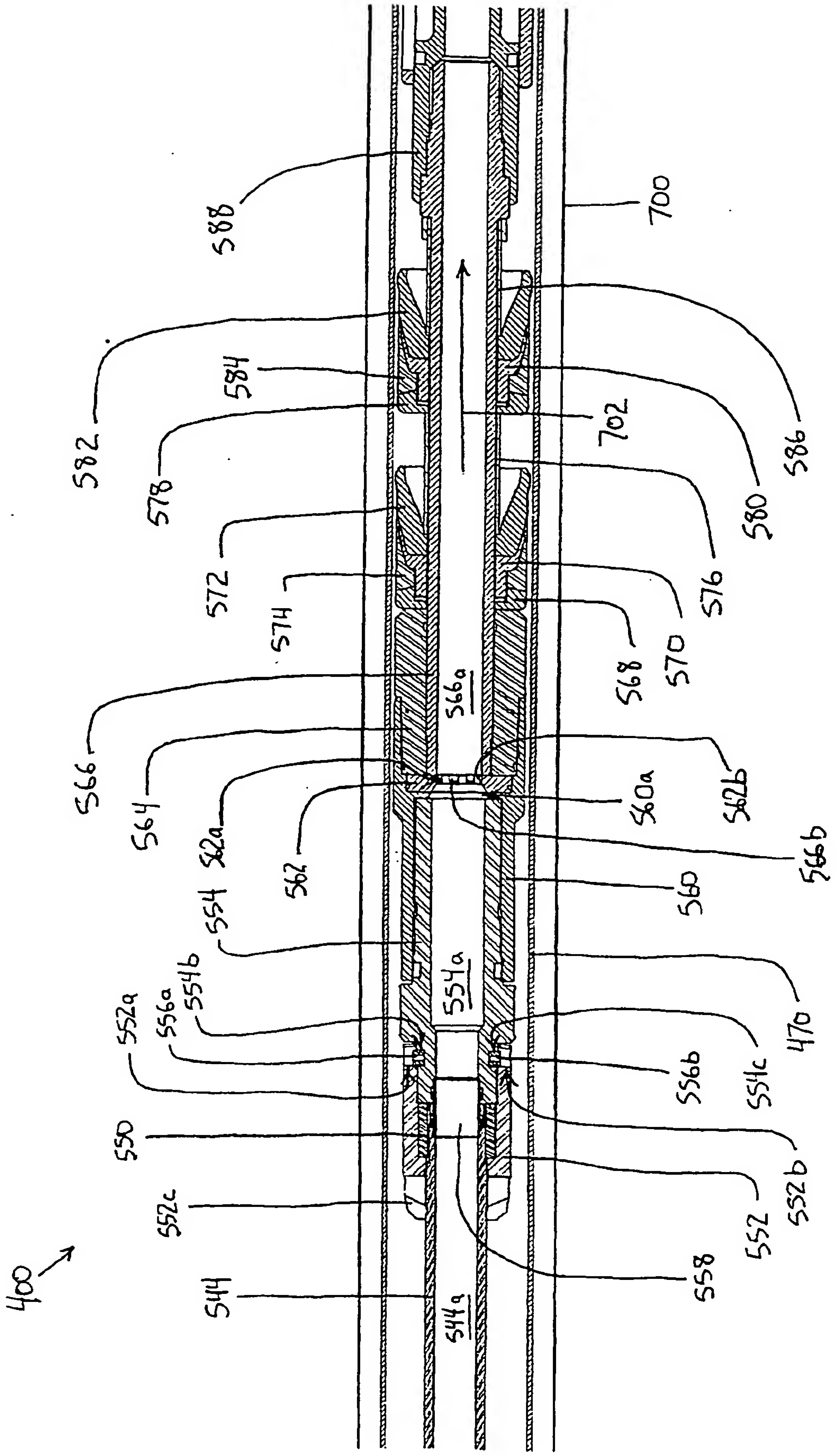

588
700
582
584
702
586
578
580
572
576
574
568
570
566a
566
564
562a
562
560a
562b
566b
560
554
554a
552a
556a
554b
556b
554c
470
550
552b
552c
552
544
544a
558
400

Fig. 26i

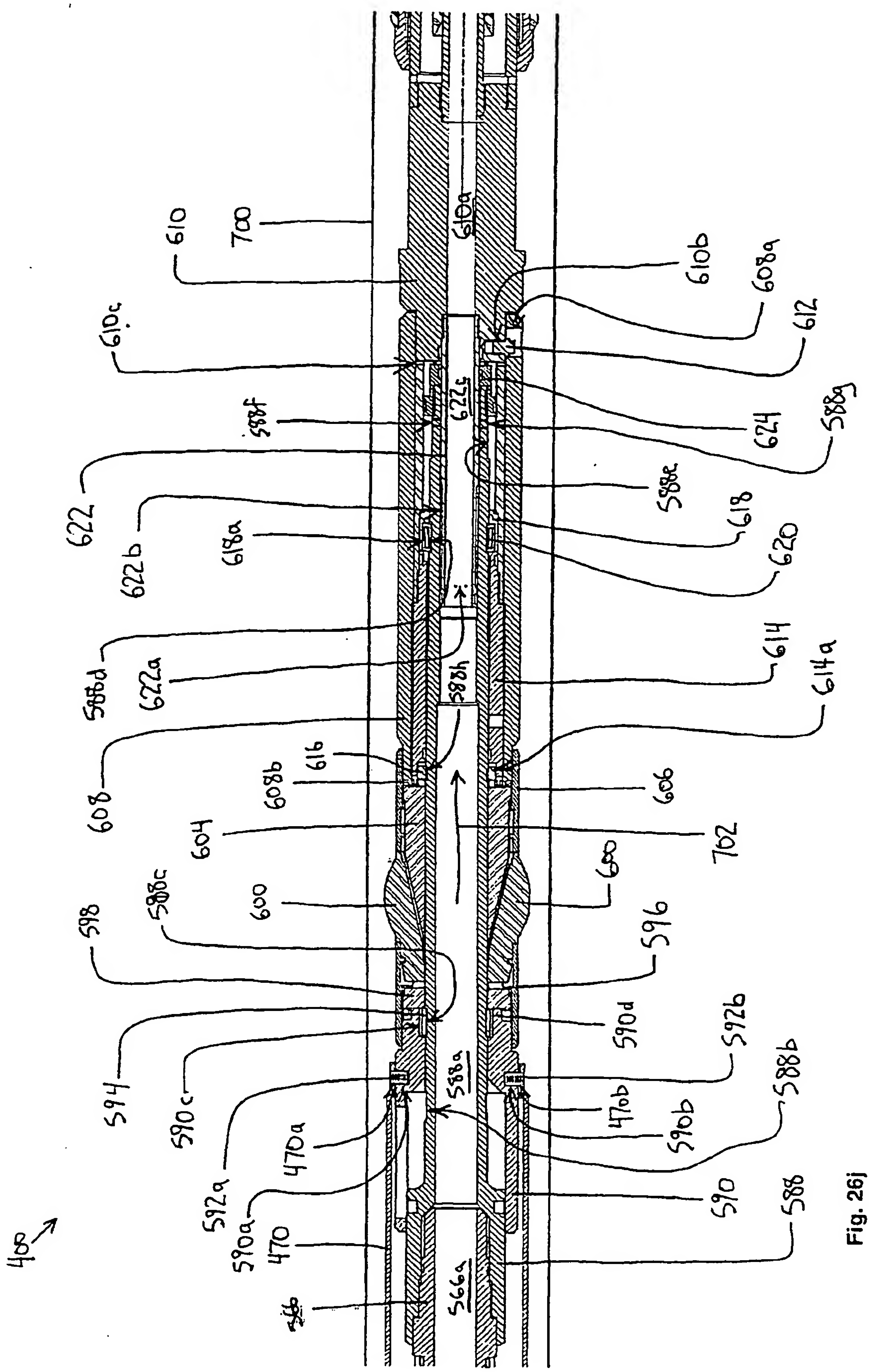


Fig. 26j

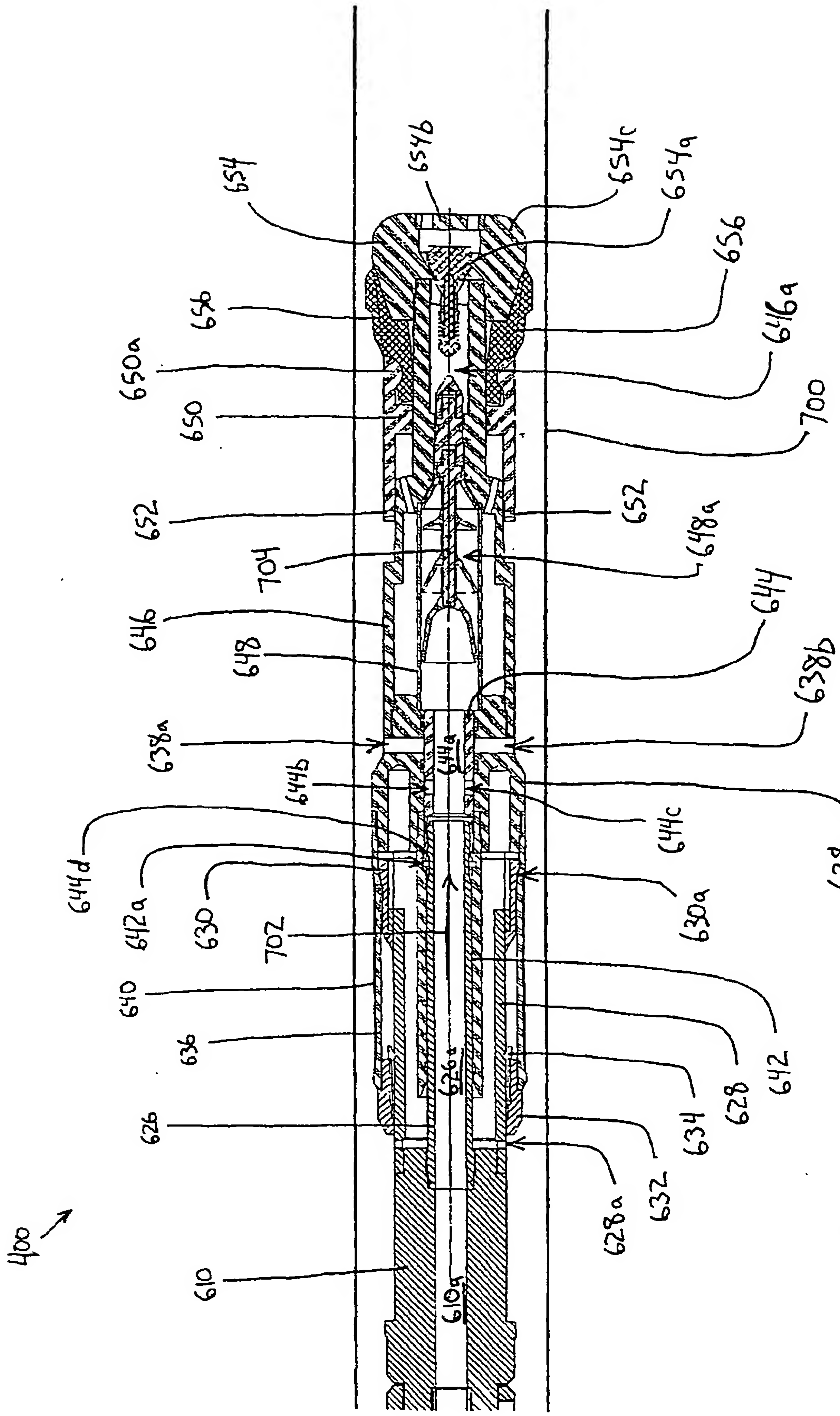

400
610
610a
628a
632
626
634
628
642
636
640
626a
702
630
630a
642a
644d
644b
644c
644a
638
638a
638b
648
644
646b
704
648a
652
652
650
700
650a
646a
656
656
654
654b
654c
654a

Fig. 26k

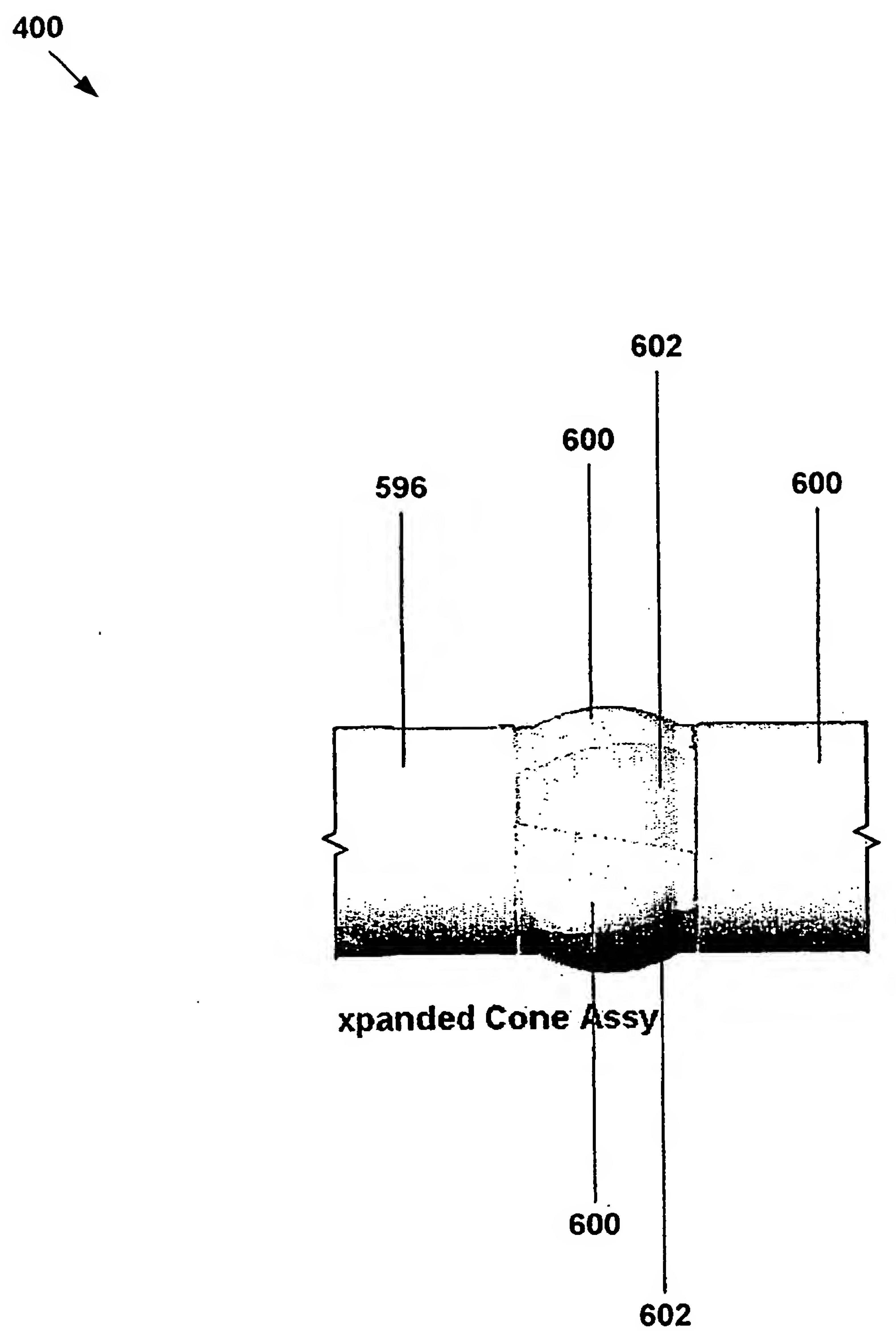


FIG. 27a

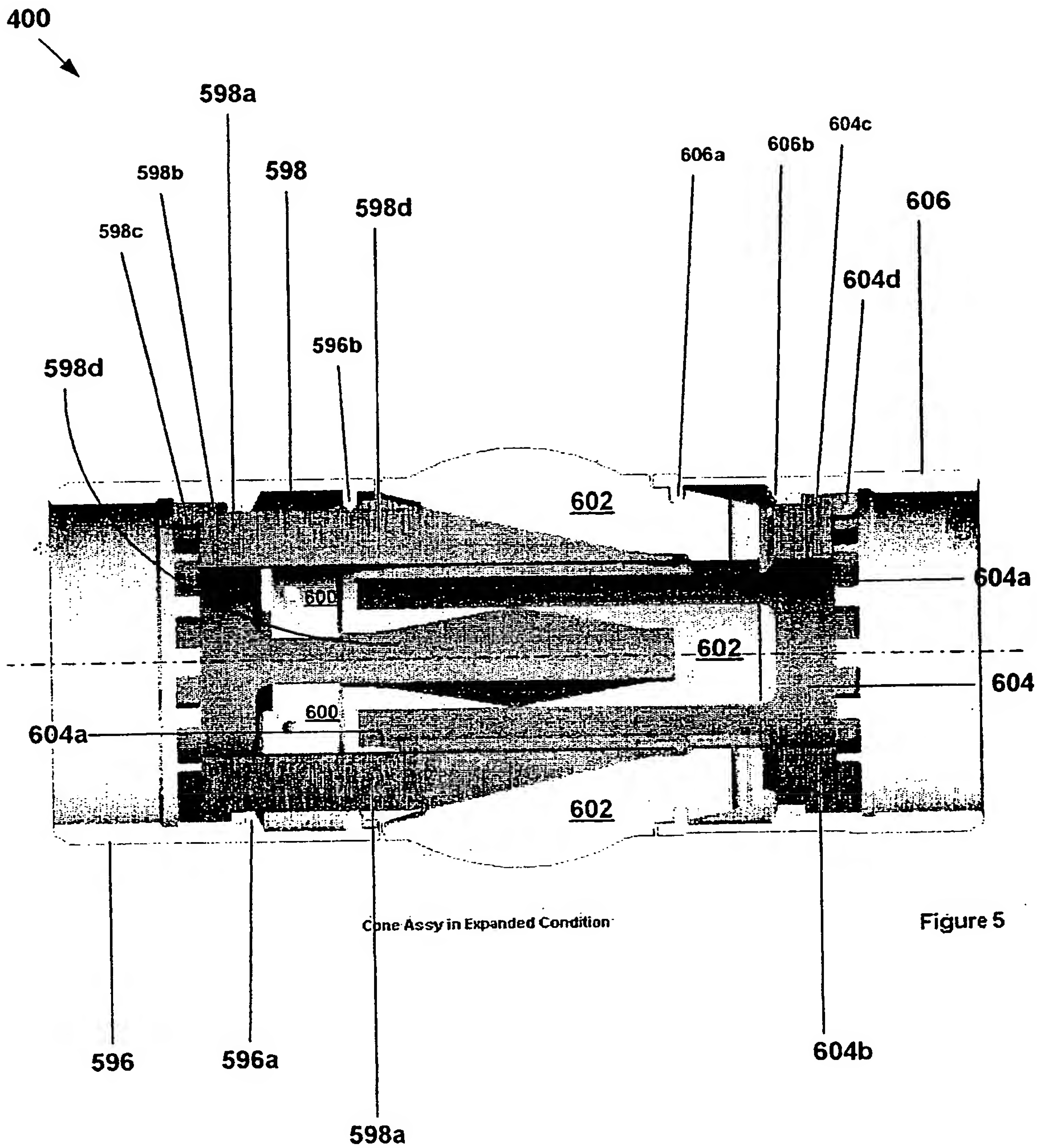

400
598a
598b
598
598d
598c
596b
598d
606a
606b
604c
606
604d
602
600
602
604a
604
600
604a
602
Cone Assy in Expanded Condition
Figure 5
596
596a
604b
598a

FIG. 27b

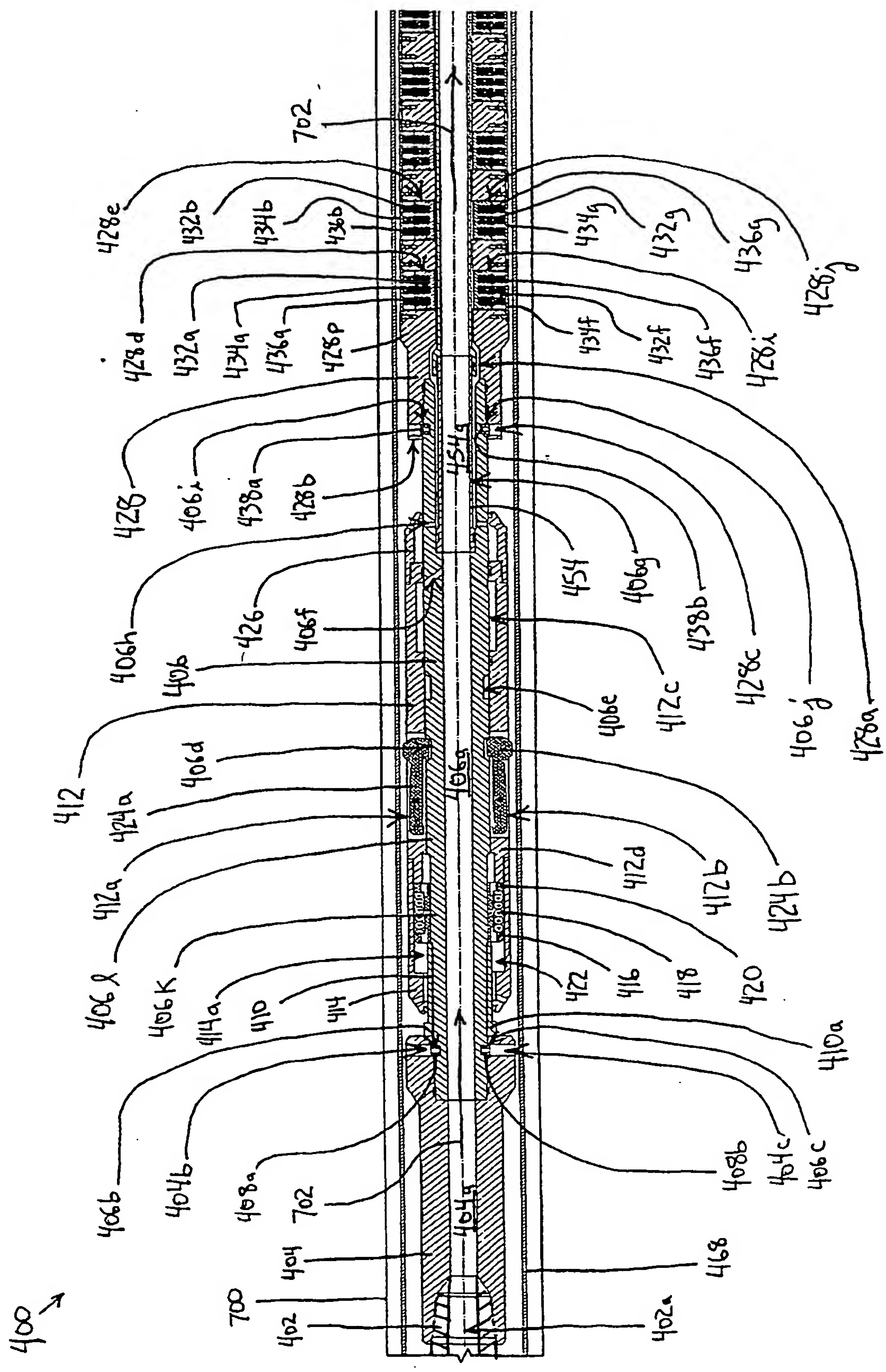

400
700
402
402a
404
404a
404b
404c
406a
406b
406c
406d
406e
406f
406g
406h
406i
406j
406k
406l
408a
408b
410
410a
412
412a
412b
412c
412d
414
414a
416
418
420
422
424a
424b
426
428
428a
428b
428c
428d
428e
428i
428j
428p
432a
432b
432f
432g
434a
434b
434f
434g
436a
436b
436f
436g
438a
438b
454
454a
468
702

Fig. 28a

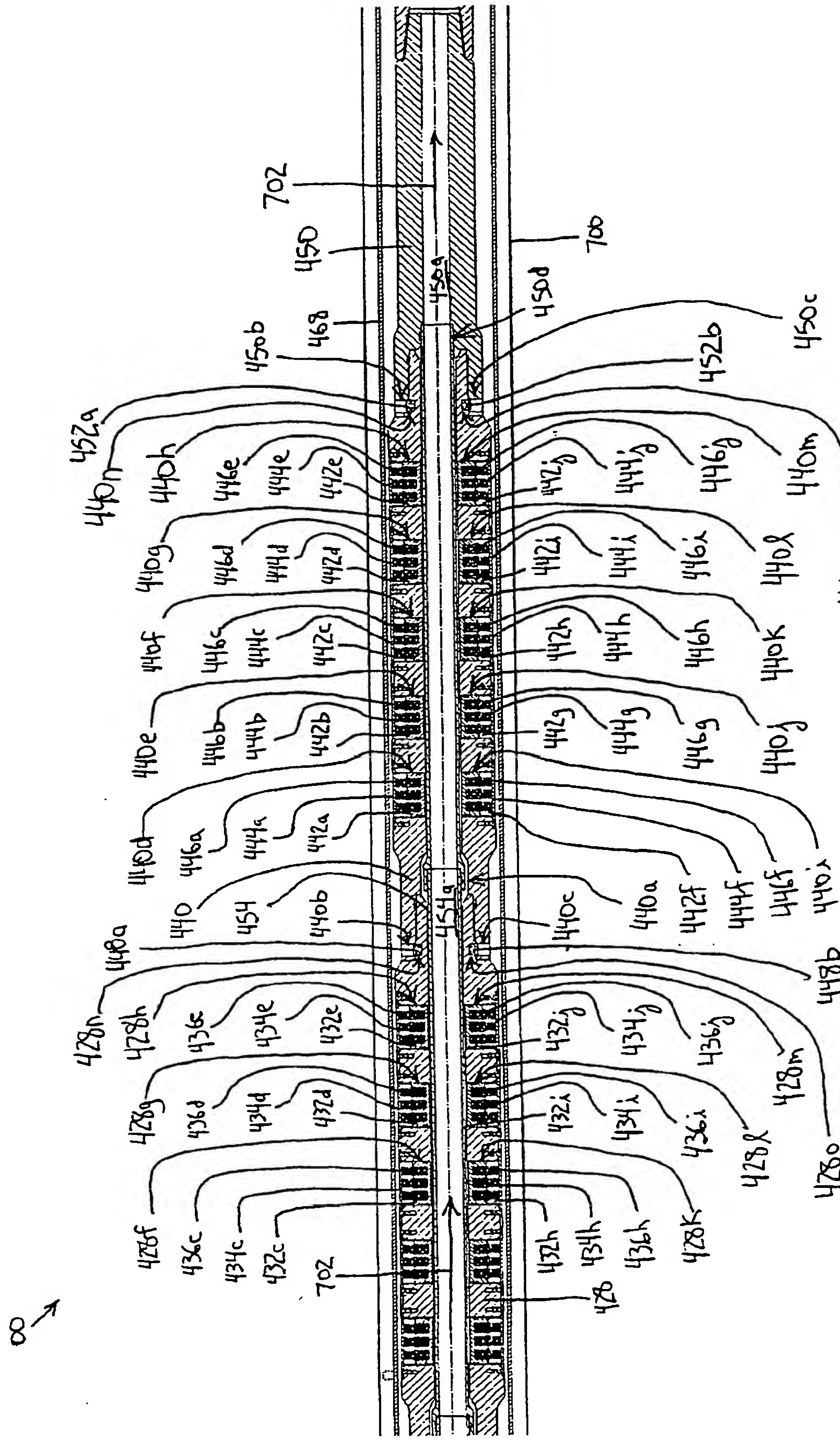


Fig. 28b

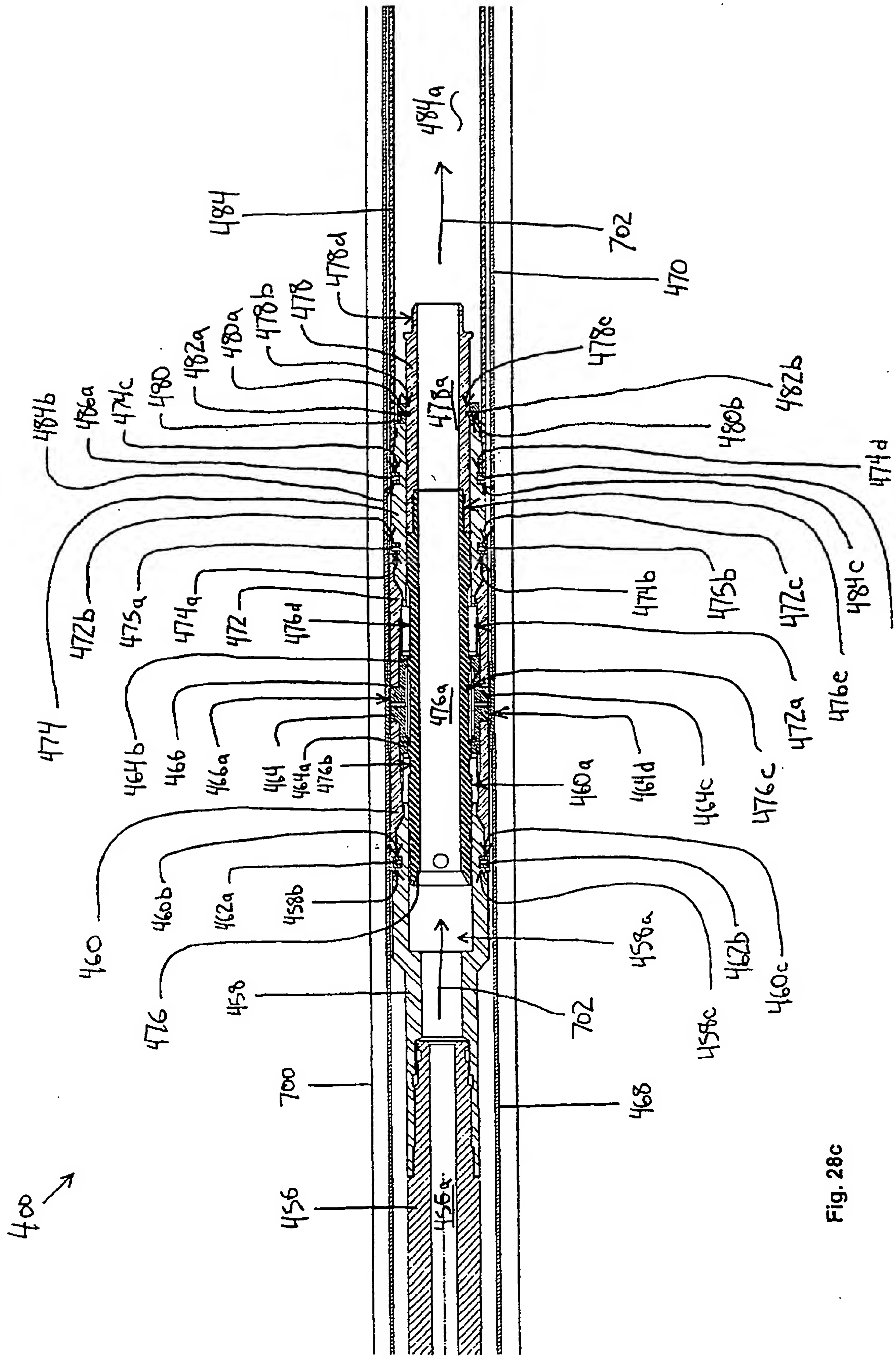

400
456
456a
700
468
458
702
476
458c
458a
460
460b
462a
458b
462b
460c
474
464b
466
466a
464
464a
476b
460a
464d
464c
476c
472b
475a
474a
472
476d
476a
472a
476e
474b
475b
472c
484c
484b
486a
474c
480
482a
480a
478b
478
478d
478a
478c
482b
480b
474d
484
470
484a

Fig. 28c

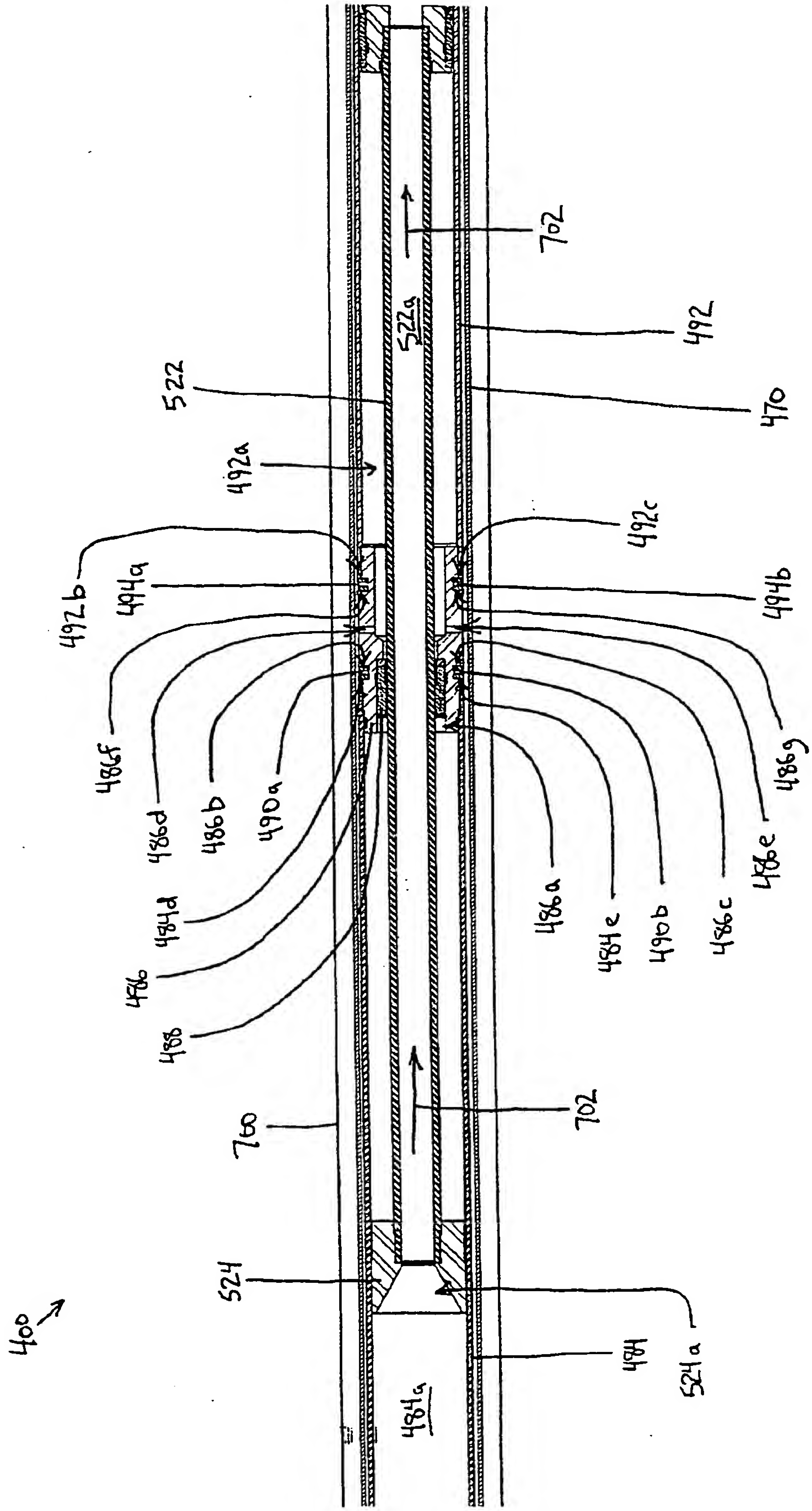

702
492
470
522
522a
492a
492c
492b
494a
494b
486f
486d
486b
490a
484d
486
488
486a
484e
490b
486c
486e
486g
760
702
524
524a
484
484a
400

Fig. 28d

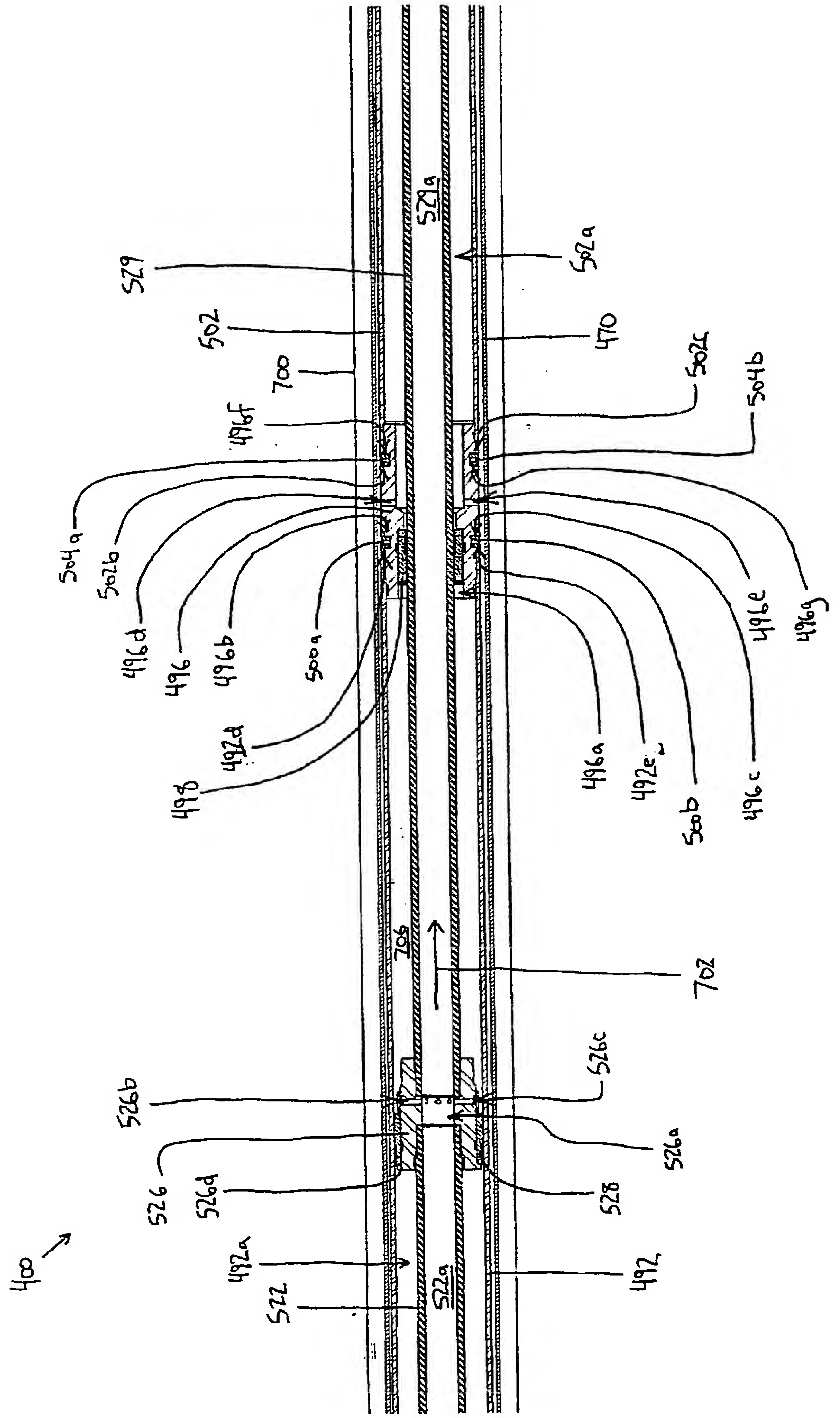

400
529
529a
502
502a
700
470
496f
502c
504b
504a
502b
496d
496
496b
500a
496e
496g
492d
498
496a
492e
500b
496c
706
702
526b
526c
526
526d
526a
528
492a
522
522a
492

Fig. 28e

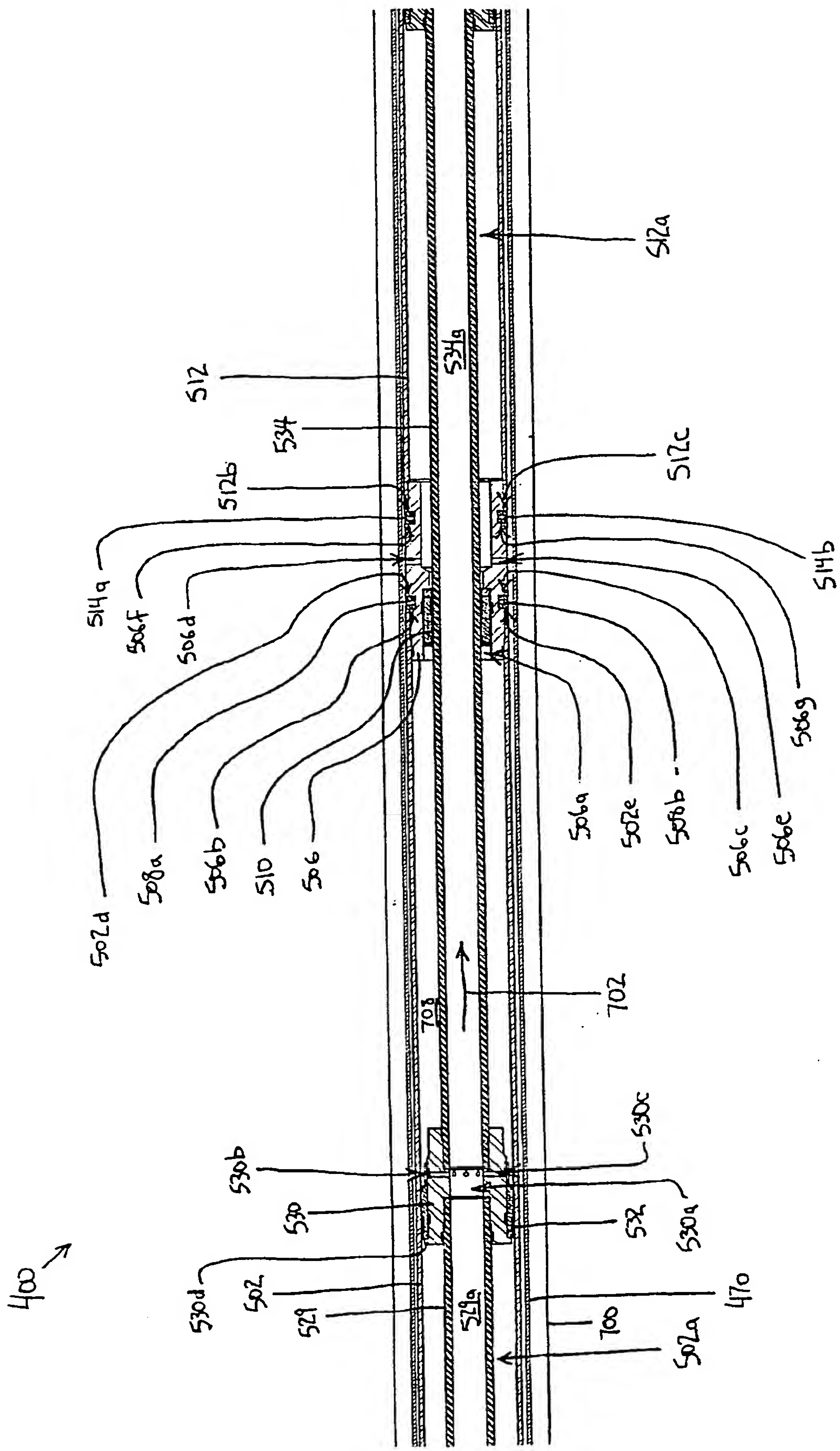

400
512a
512
534
534a
512b
512c
514a
506f
506d
514b
502d
508a
506b
510
506
506a
502e
508b
506c
506e
506g
702
703
530b
530c
530
532
530a
530d
502
529
529a
470
700
502a

Fig. 28f

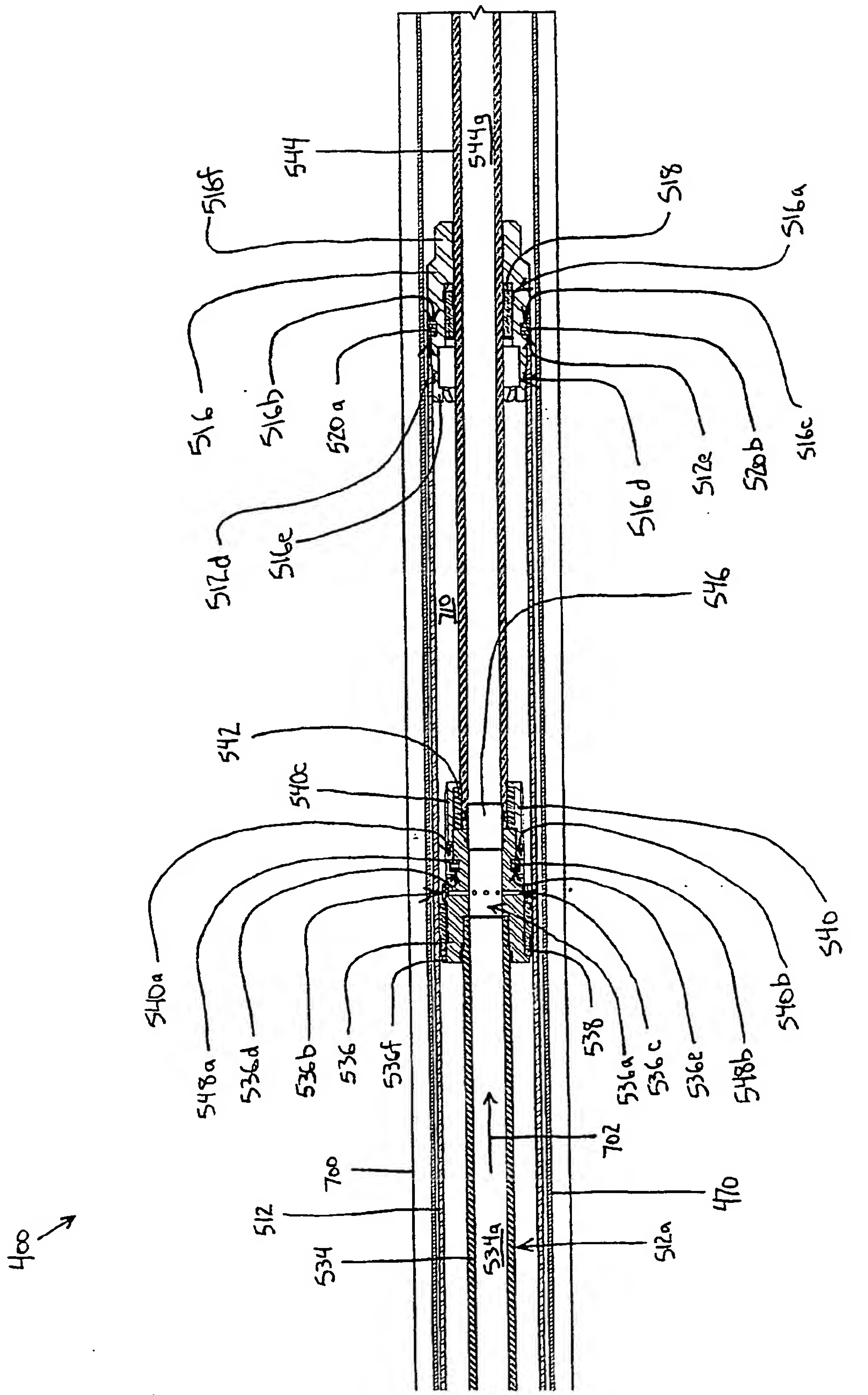

516f
544
544g
518
516a
516
516b
520a
516d
512e
520b
516c
512d
516e
710
546
542
540c
540a
548a
536d
536b
536
536f
538
536a
536c
536e
548b
540b
540
700
702
512
470
400
534
534a
512a

Fig. 28g

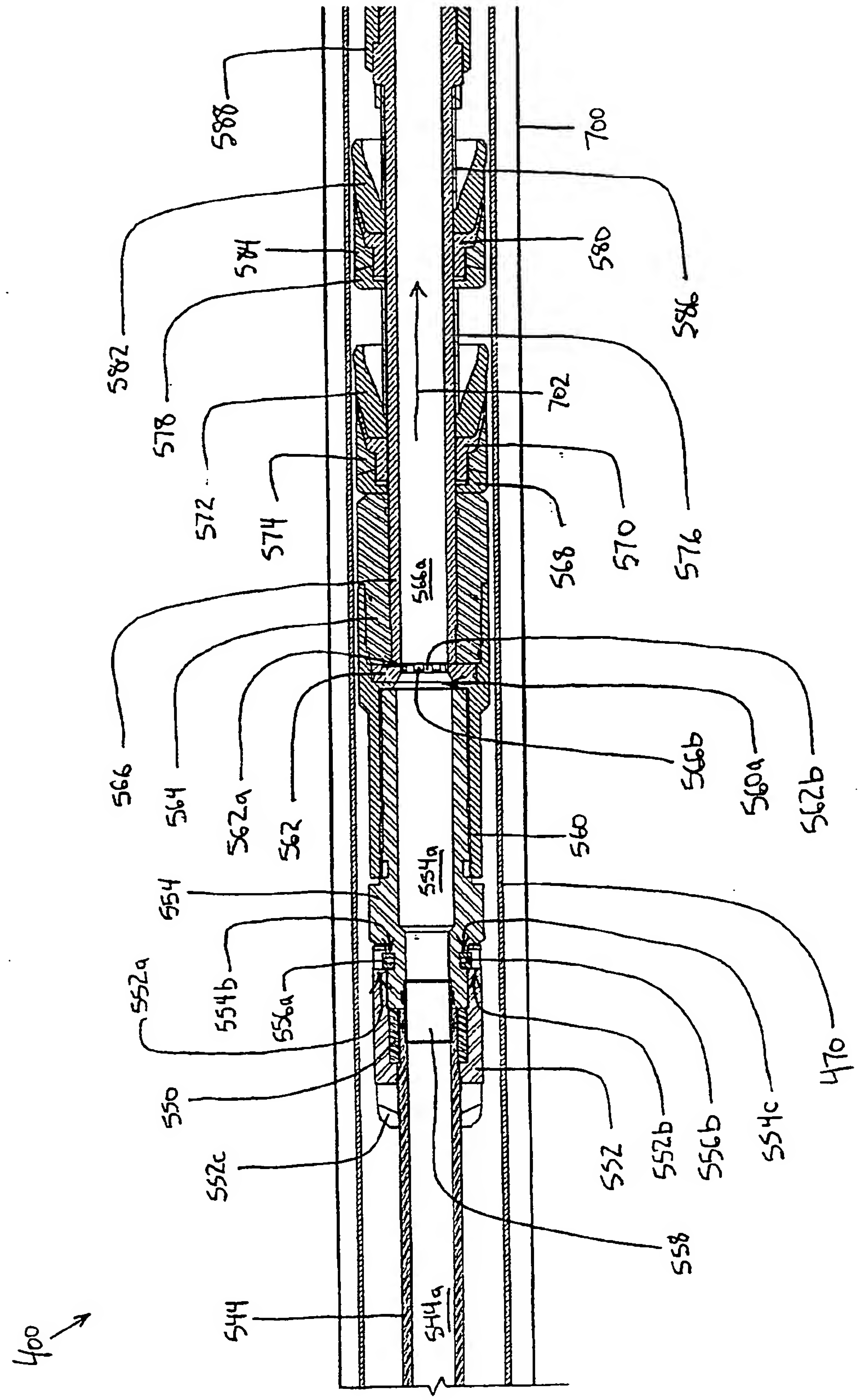

400
588
582
574
578
572
574
566
564
562a
562
552a
554b
556a
550
552c
544
544a
700
580
586
702
570
576
568
566a
566b
560a
562b
560
554a
554
470
552
552b
556b
554c
558

Fig. 28h

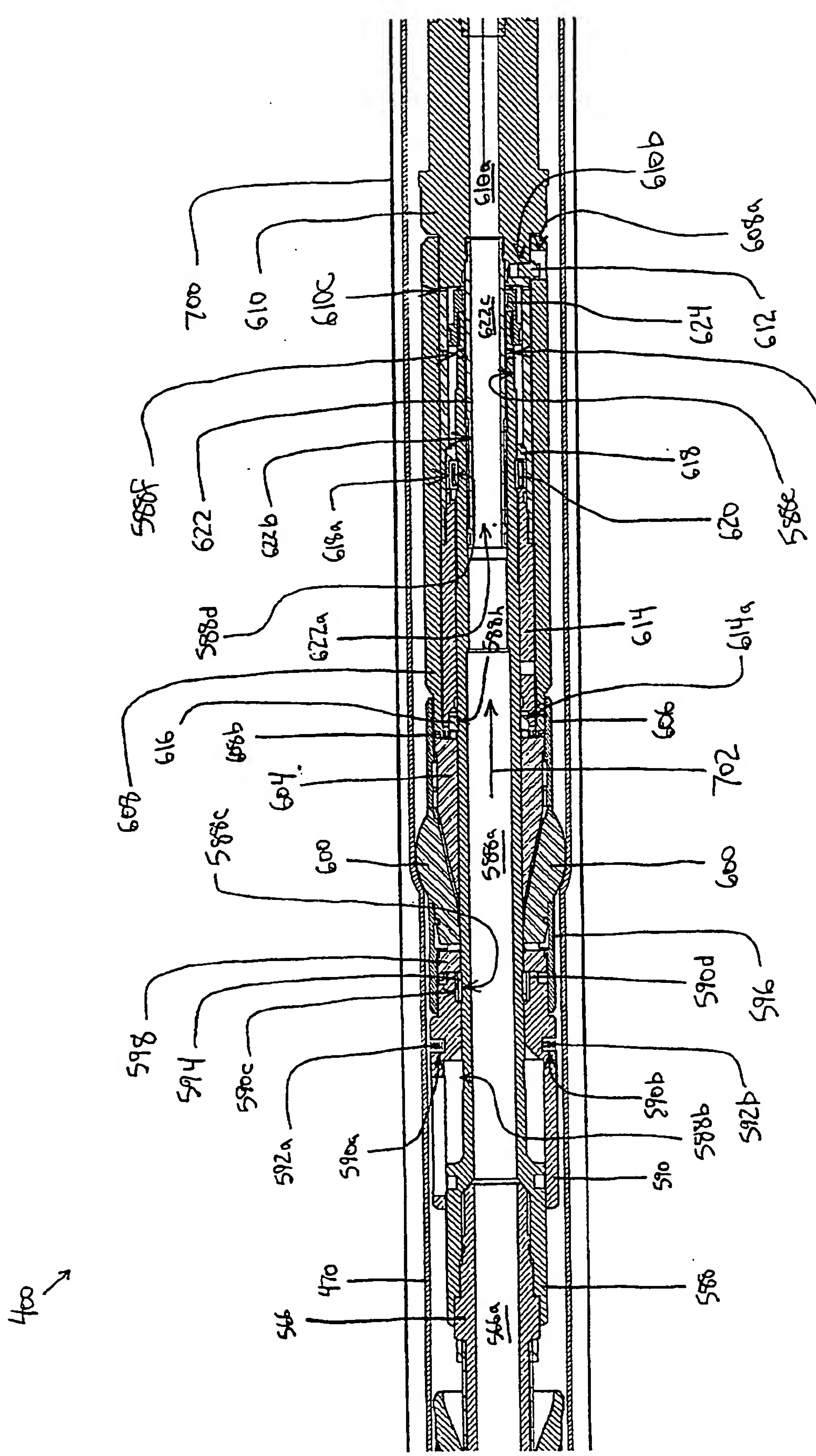

700
610
610c
610b
608a
612
624
622c
610a
588f
622
622b
618a
618
620
588e
588g
588d
622a
588h
614
614a
608
616
606
604
702
588c
600
600
588a
598
594
590c
590d
596
592b
590b
588b
592a
590a
590
470
566
566a
586
400

Fig. 28i

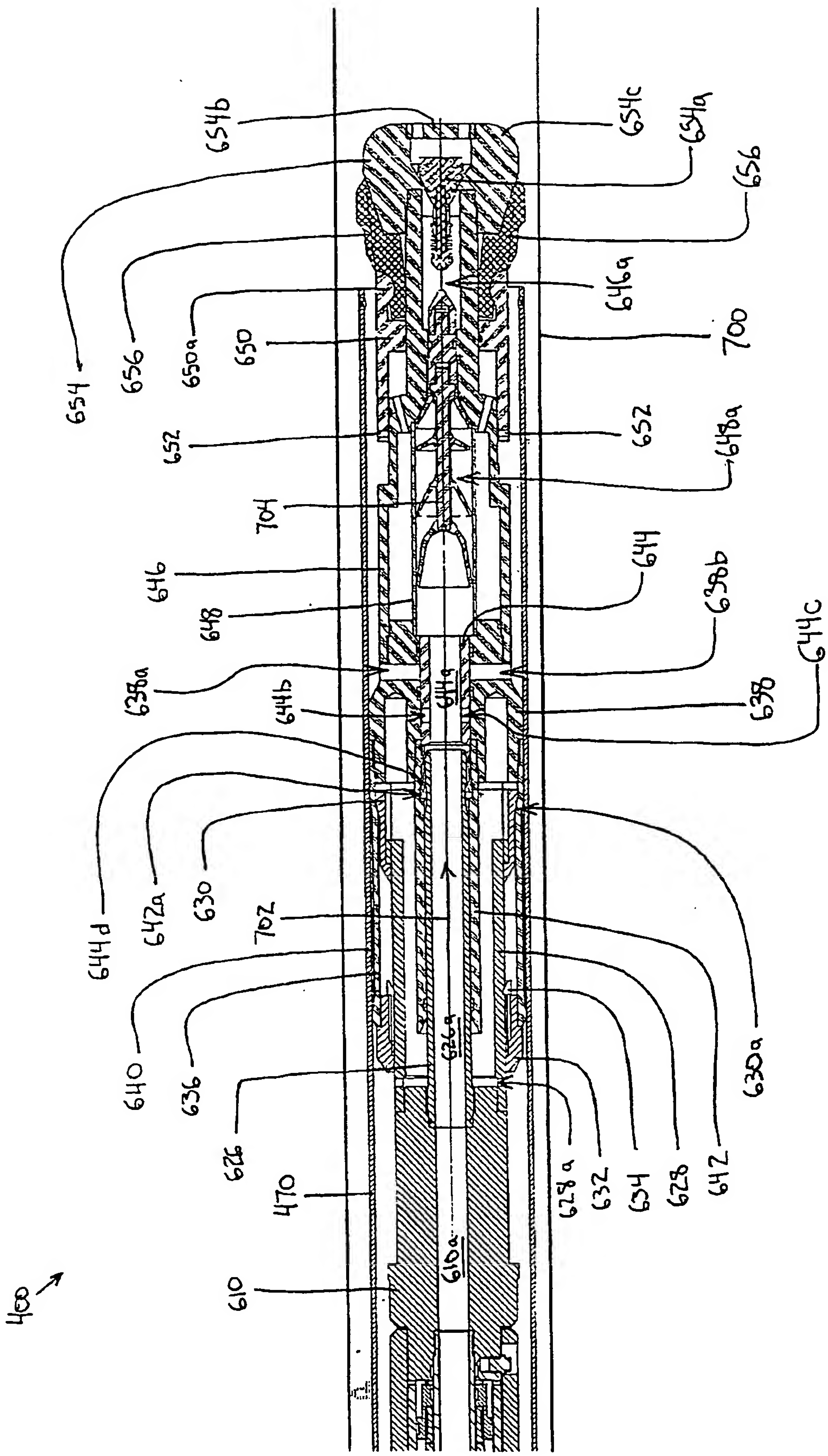

400
654b
654c
654a
656
654
656
650a
650
646a
700
652
652
648a
704
646
648
644
638b
644c
638a
644b
644a
638
644d
642a
630
702
630a
640
636
626a
626
470
628a
632
634
628
642
610
610a

Fig. 28I

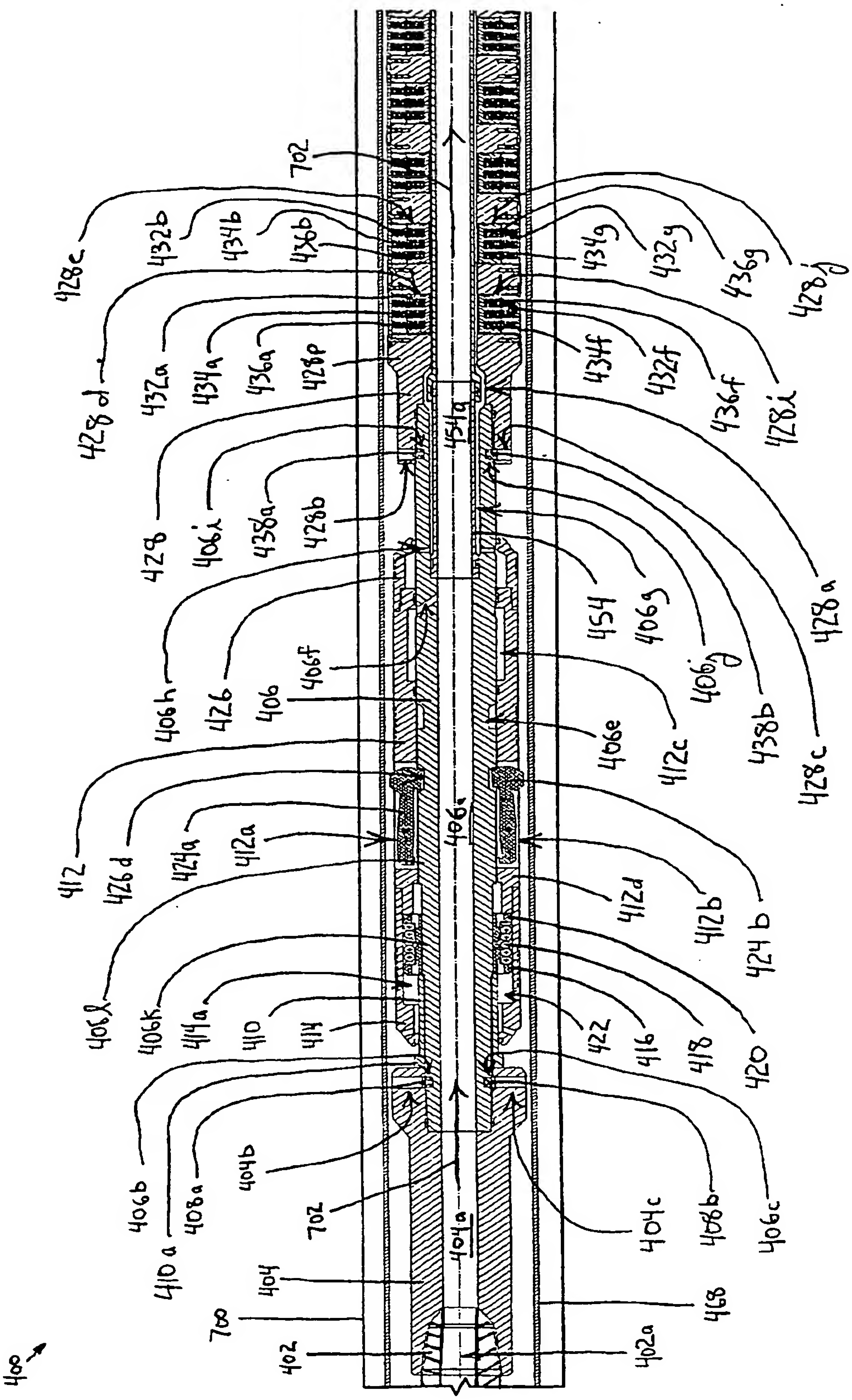

400
402
402a
404
404a
404b
404c
406
406b
406c
406e
406f
406g
406h
406i
406j
406k
406l
408a
408b
410
410a
412
412a
412b
412c
412d
414
414a
416
418
420
422
424a
424b
426
426d
428
428a
428b
428c
428d
428e
428i
428j
428p
432a
432b
432f
432g
434a
434b
434f
434g
436a
436b
436f
436g
438a
438b
454
454a
468
700
702

Fig. 29a

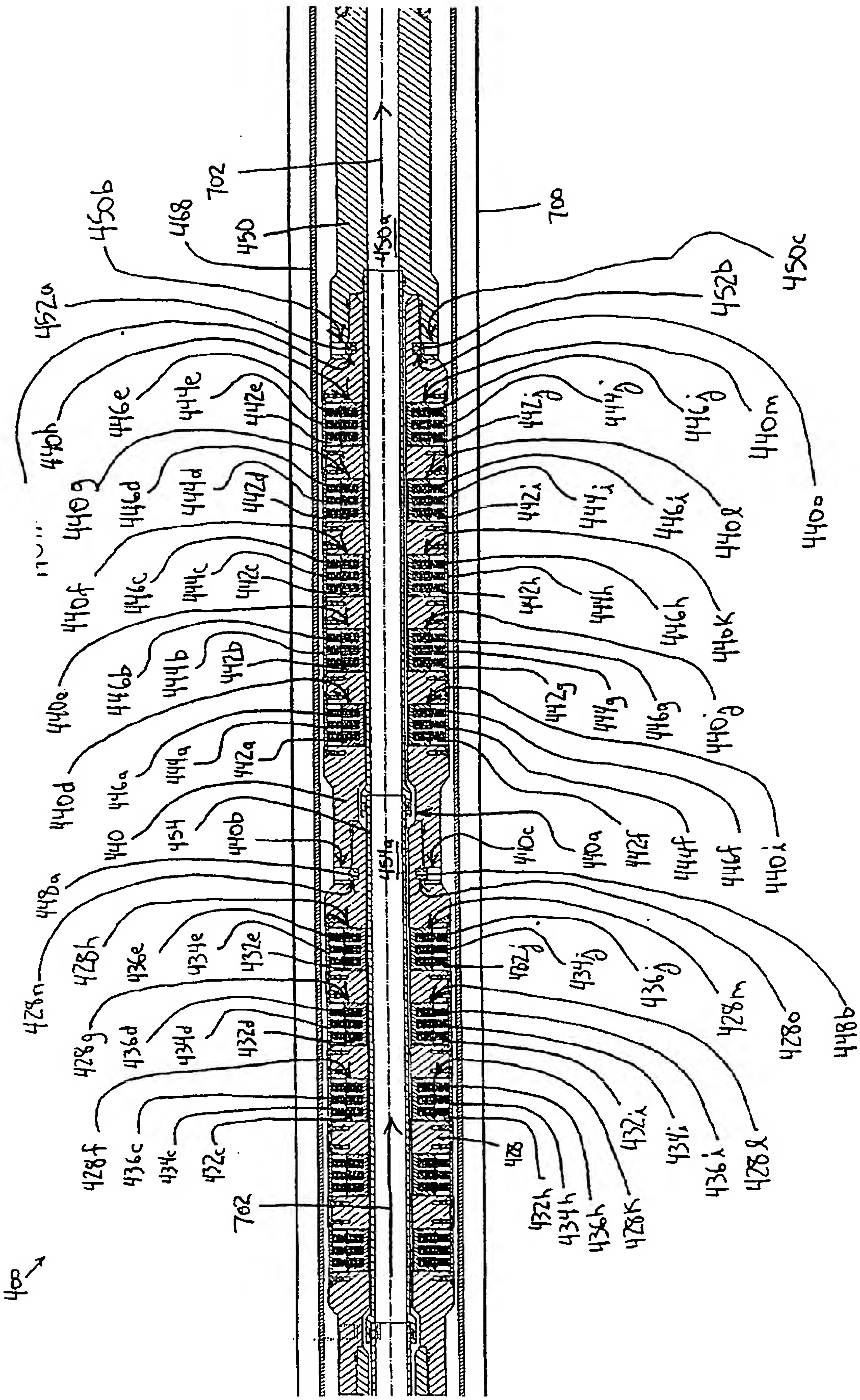


Fig. 29b

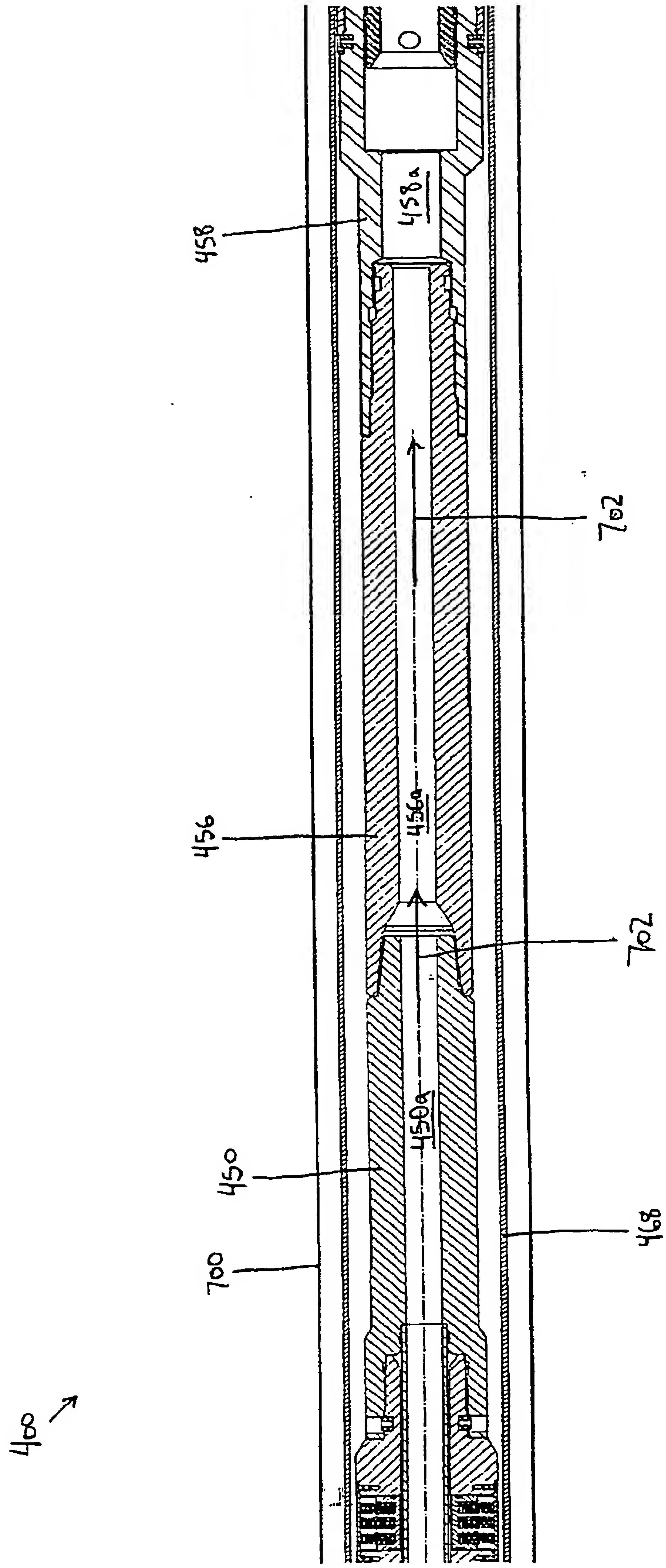


Fig. 29c

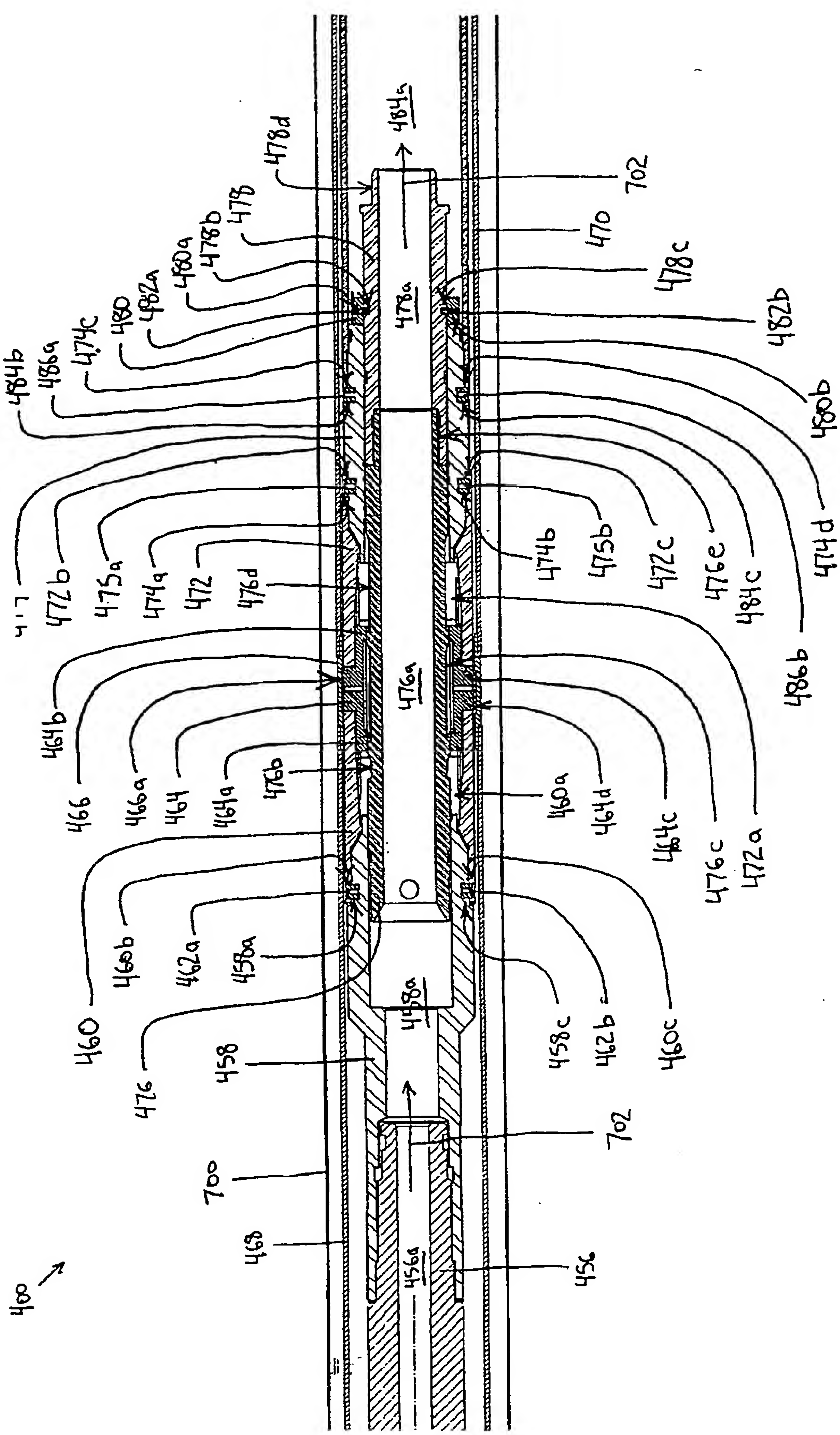

400
700
702
458
476
460
460b
462a
458a
458c
462b
460c
466
464b
466a
464
464a
476b
460a
464d
464c
476c
472a
472b
475a
474a
472
476d
476a
474b
475b
472c
476e
484c
486b
474d
480b
482b
478c
470
478a
478
478b
480a
482a
480
474c
486a
484b
478d
484a
456
456a
468

Fig. 29d

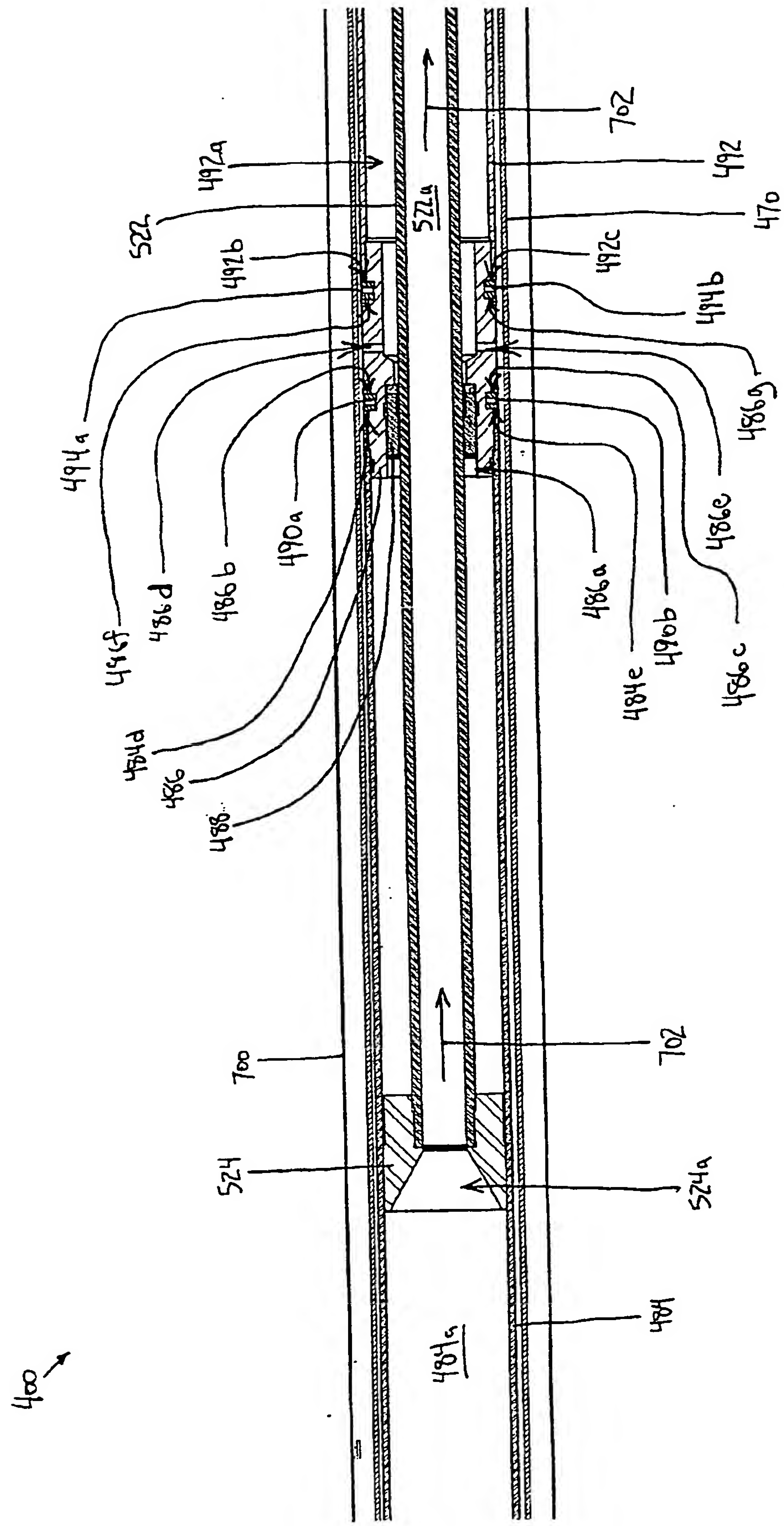

702
492a
492
522
522a
470
492b
492c
494b
494a
486g
494f
486d
486b
490a
486e
486a
486c
484e
490b
484d
486
488
700
702
524
524a
484
484a
400

Fig. 29e

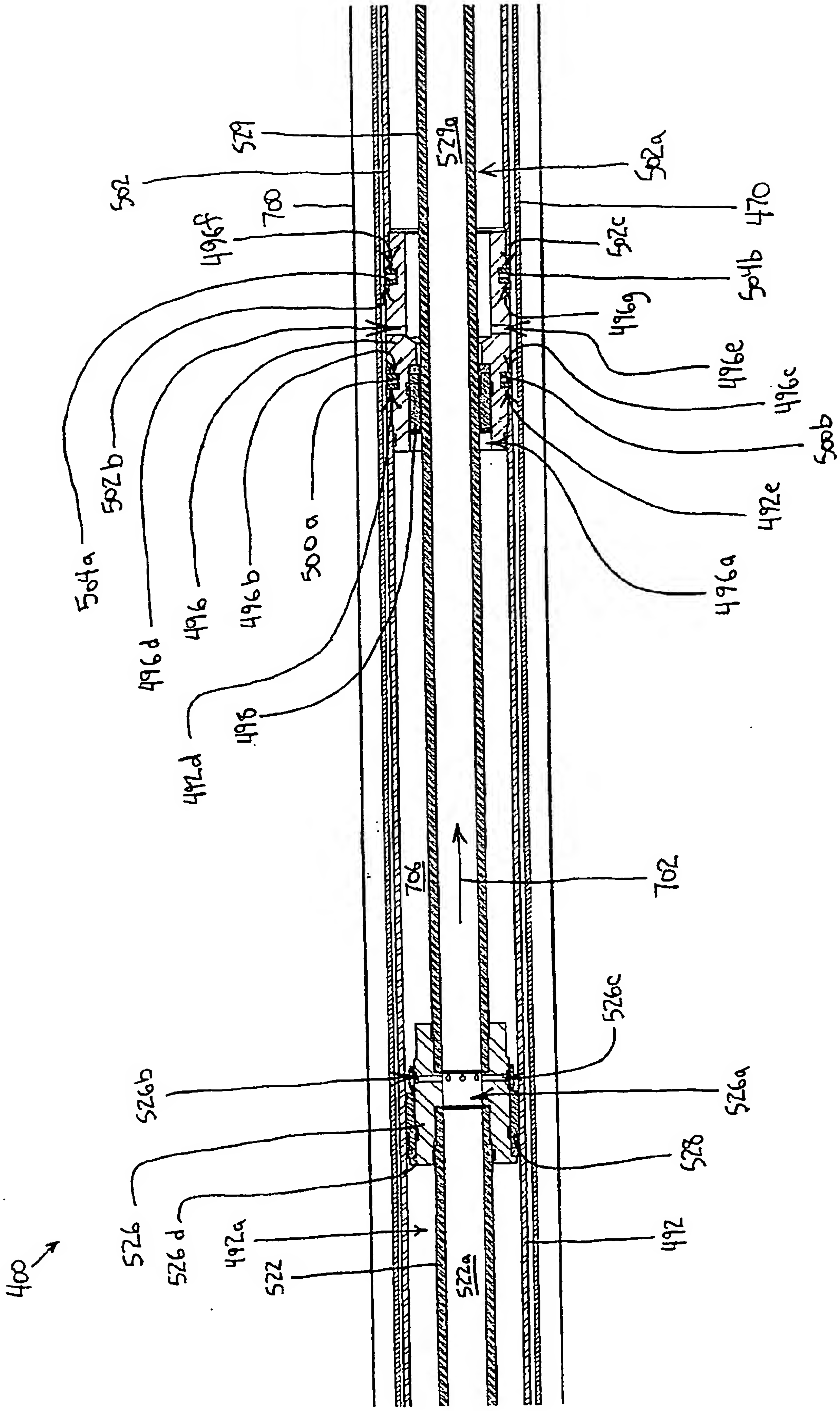

400
526
526d
492a
522
522a
526b
526c
526a
528
492
706
702
504a
502b
496d
496
496b
500a
492d
498
502
529
529a
700
496f
502a
470
502c
504b
496g
496e
496c
500b
492e
496a

Fig. 29f

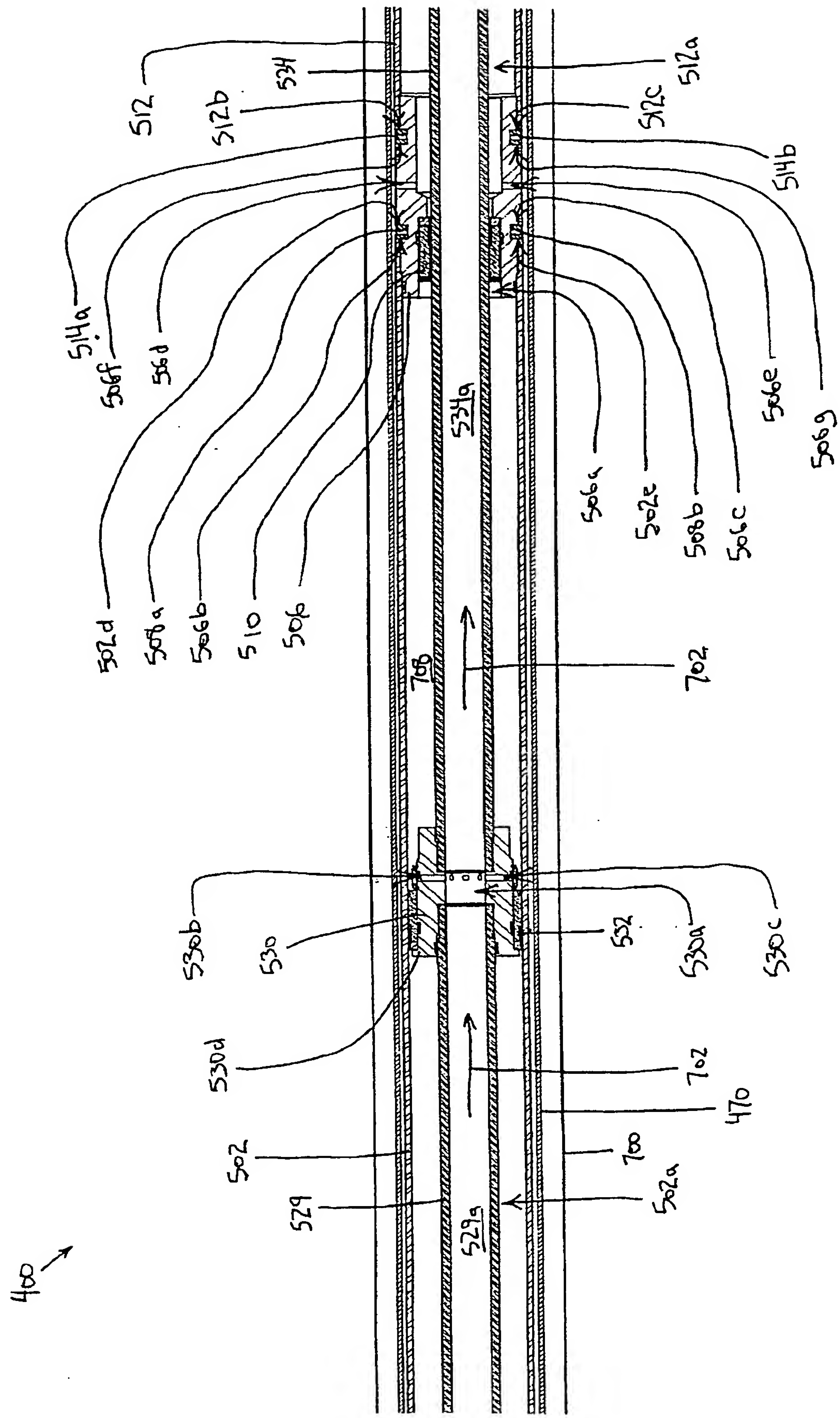

400
512
512b
534
512a
512c
514b
514a
506f
506d
534a
506a
502e
508b
506c
506e
506g
502d
508a
506b
510
506
708
702
530b
530
532
530a
530c
530d
702
470
502
700
529
529a
502a

Fig. 29g

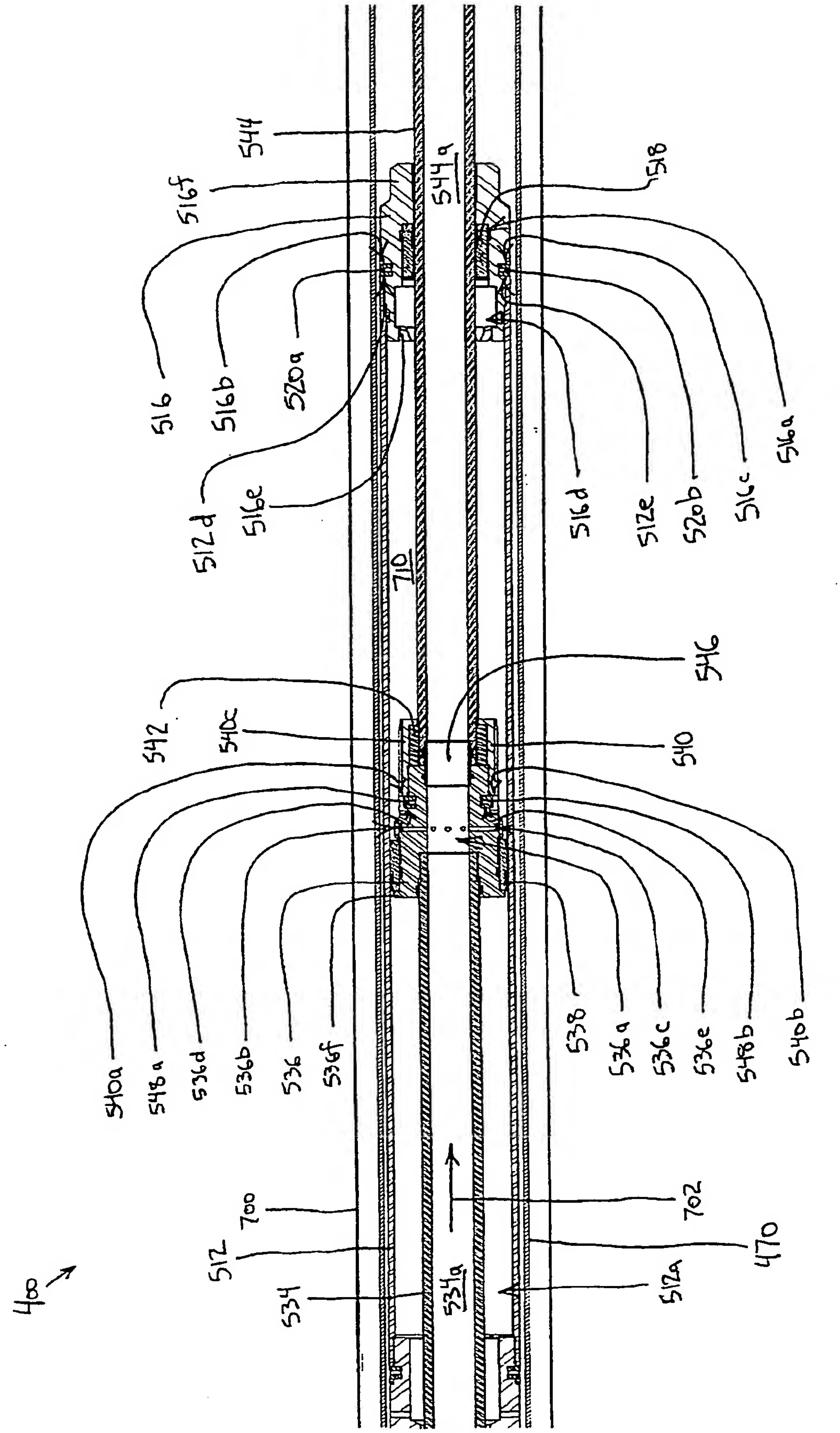

400
544
544a
516f
518
516
516b
520a
512d
516e
516d
512e
520b
516c
516a
710
542
540c
546
540
540a
548a
536d
536b
536
536f
538
536a
536c
536e
548b
540b
700
512
534
534a
702
470
512a

Fig. 29h

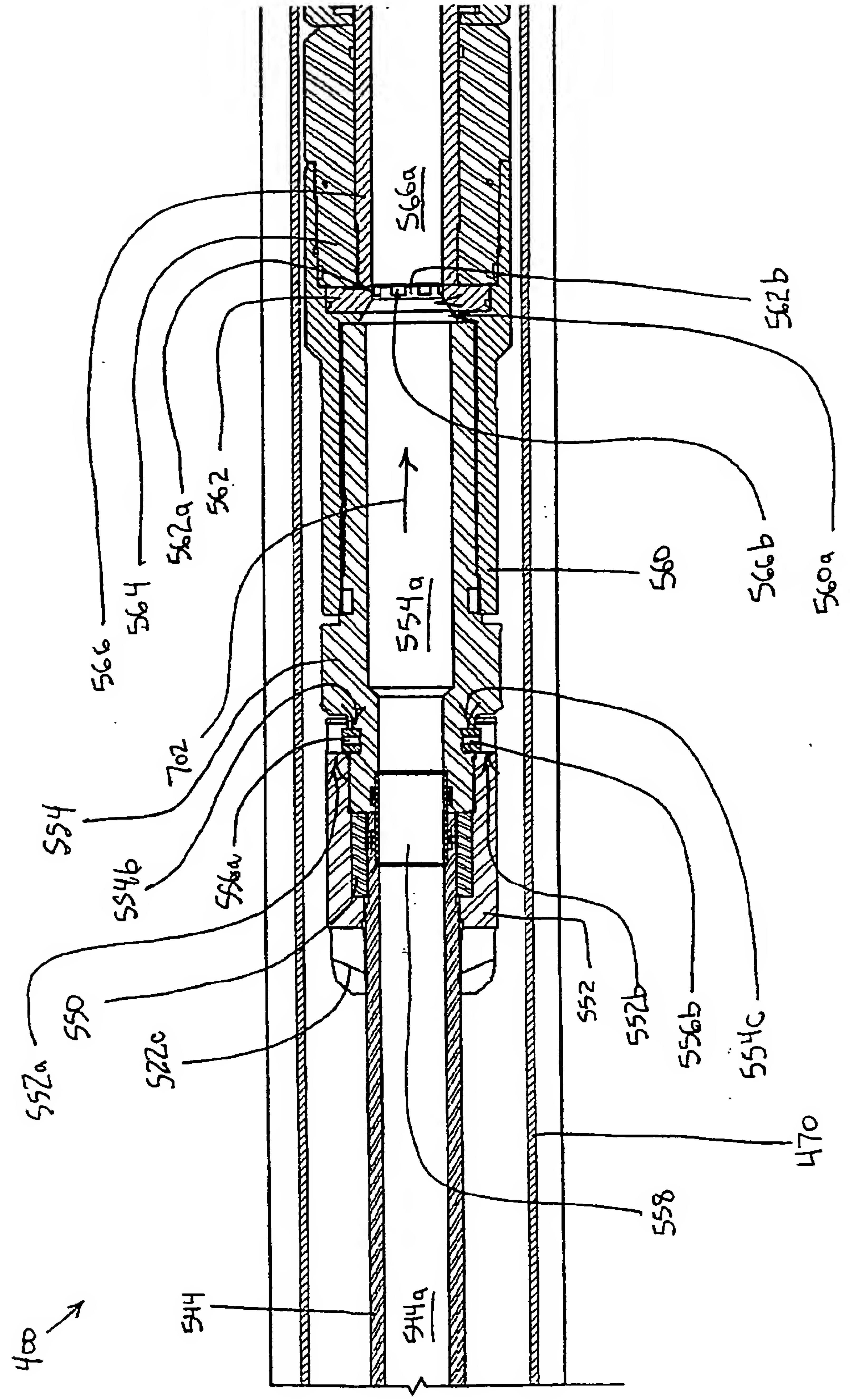
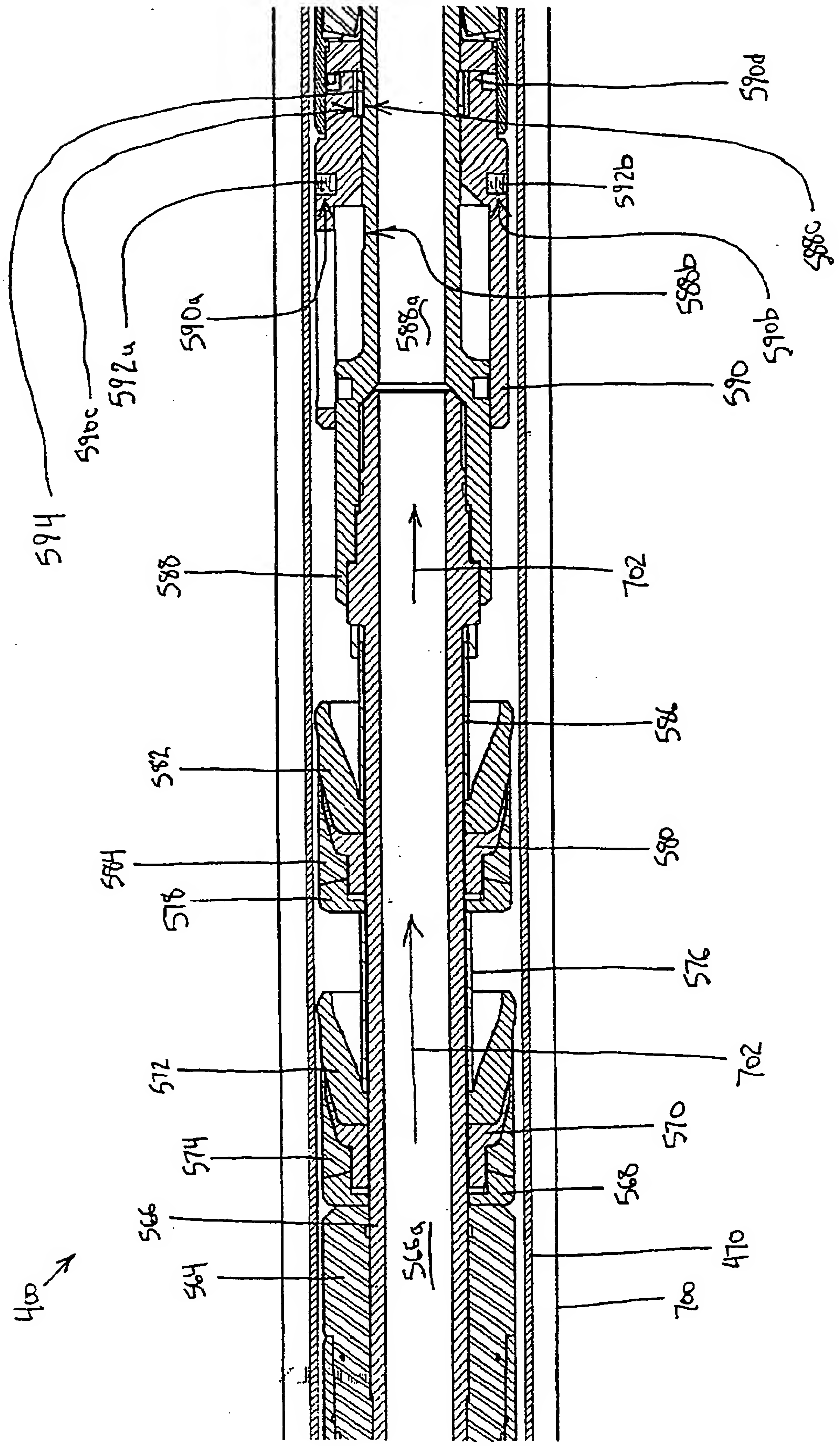

566a
562b
566
564
562a
562
566b
560a
560
554a
702
554
554b
556a
552a
550
522c
552
552b
556b
554c
470
558
544
544a
400

Fig. 29I



400
564
566
566a
574
572
578
584
582
588
594
590c
592a
590a
588a
588b
588c
590d
592b
590b
590
702
586
580
576
702
570
568
470
700

Fig. 29J

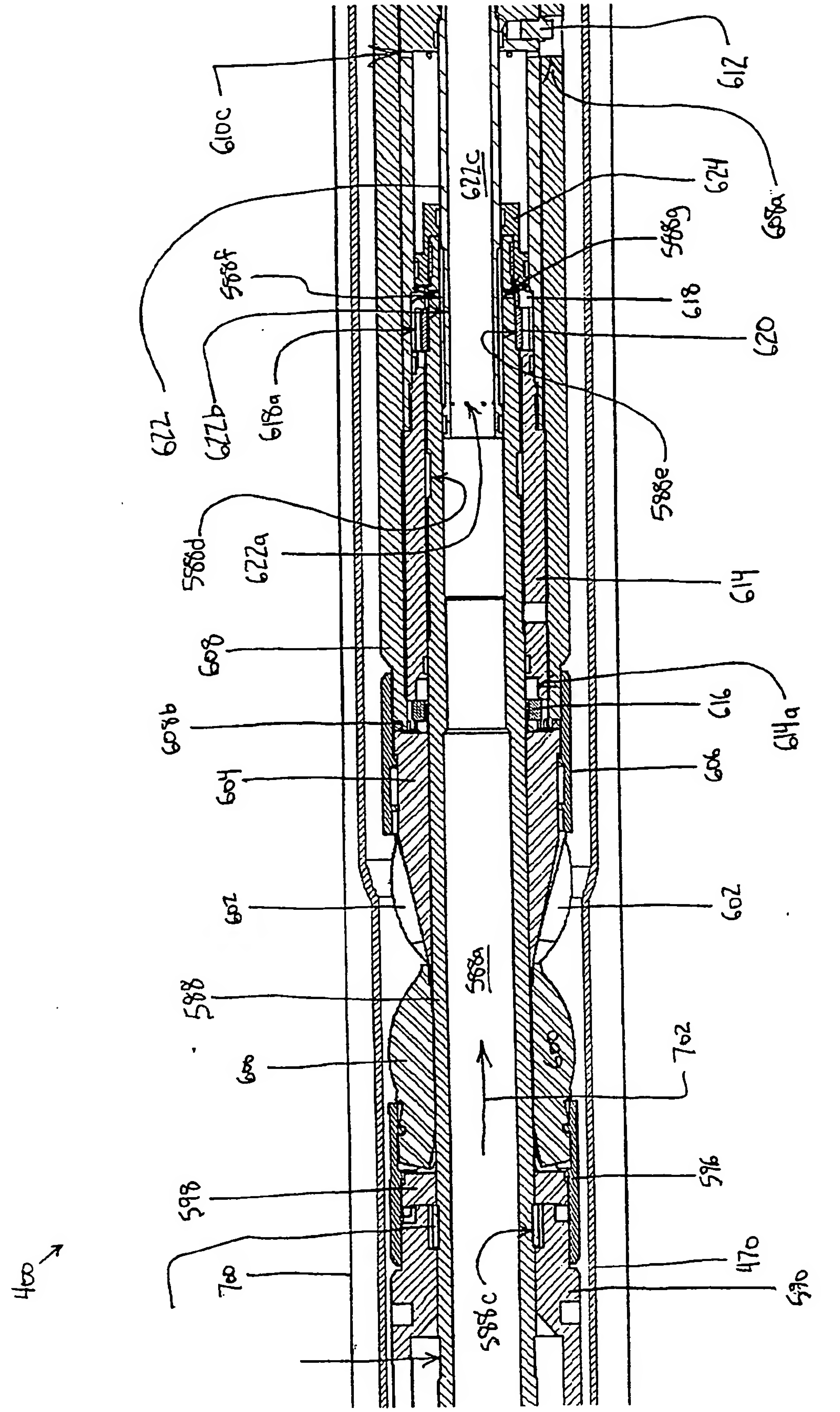
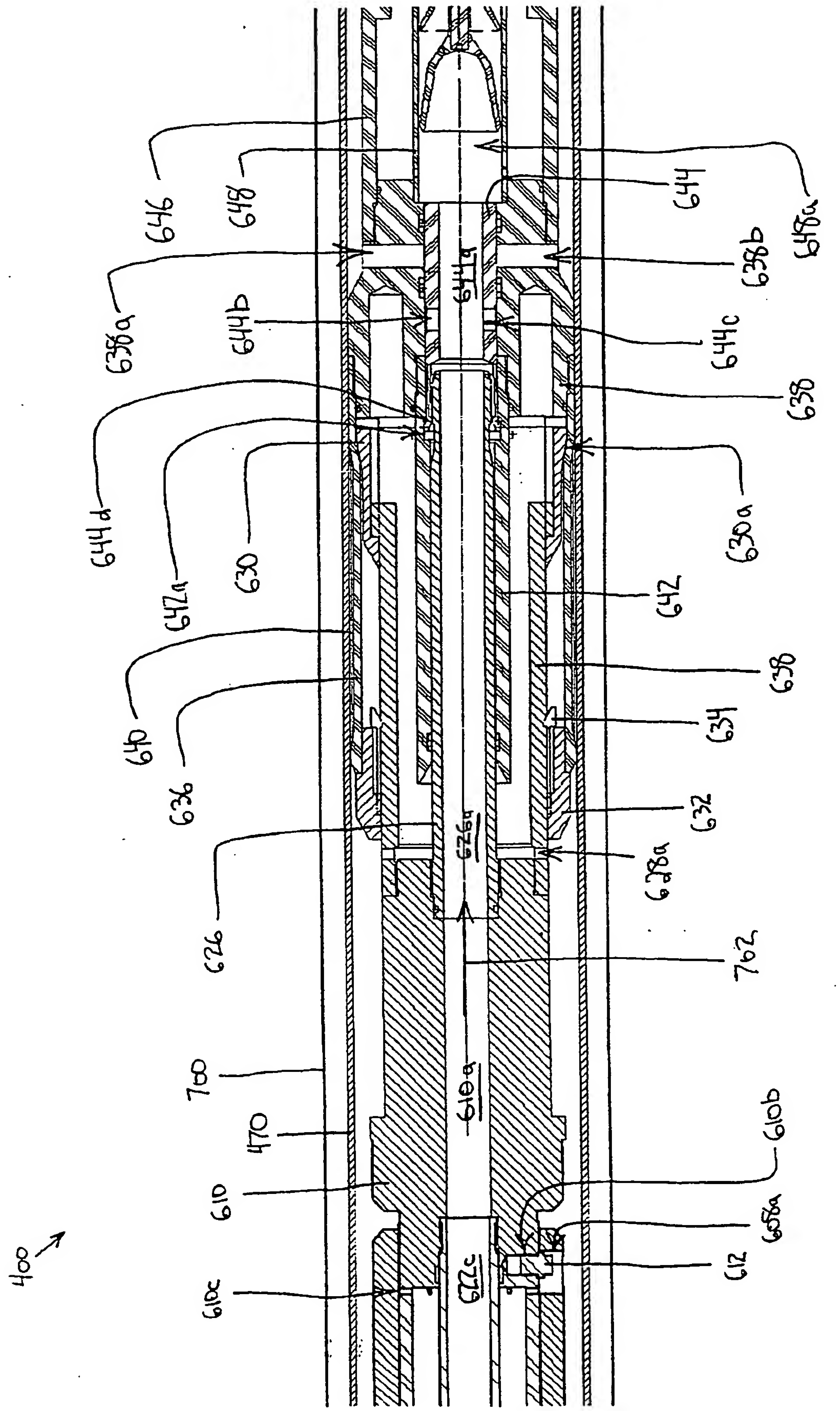

400
610c
622
622b
618a
588f
622c
612
608a
624
588g
618
620
588e
588d
622a
614
608
608b
604
616
614a
606
602
602
588
588a
600
702
598
700
596
588c
470
590

Fig. 29k



646
648
644
648a
636a
636b
644a
644b
644c
638
644d
642a
630
630a
642
640
638
636
634
632
626
626a
628a
762
700
470
610a
610b
610
656a
612
400
610c
622c

Fig. 29I

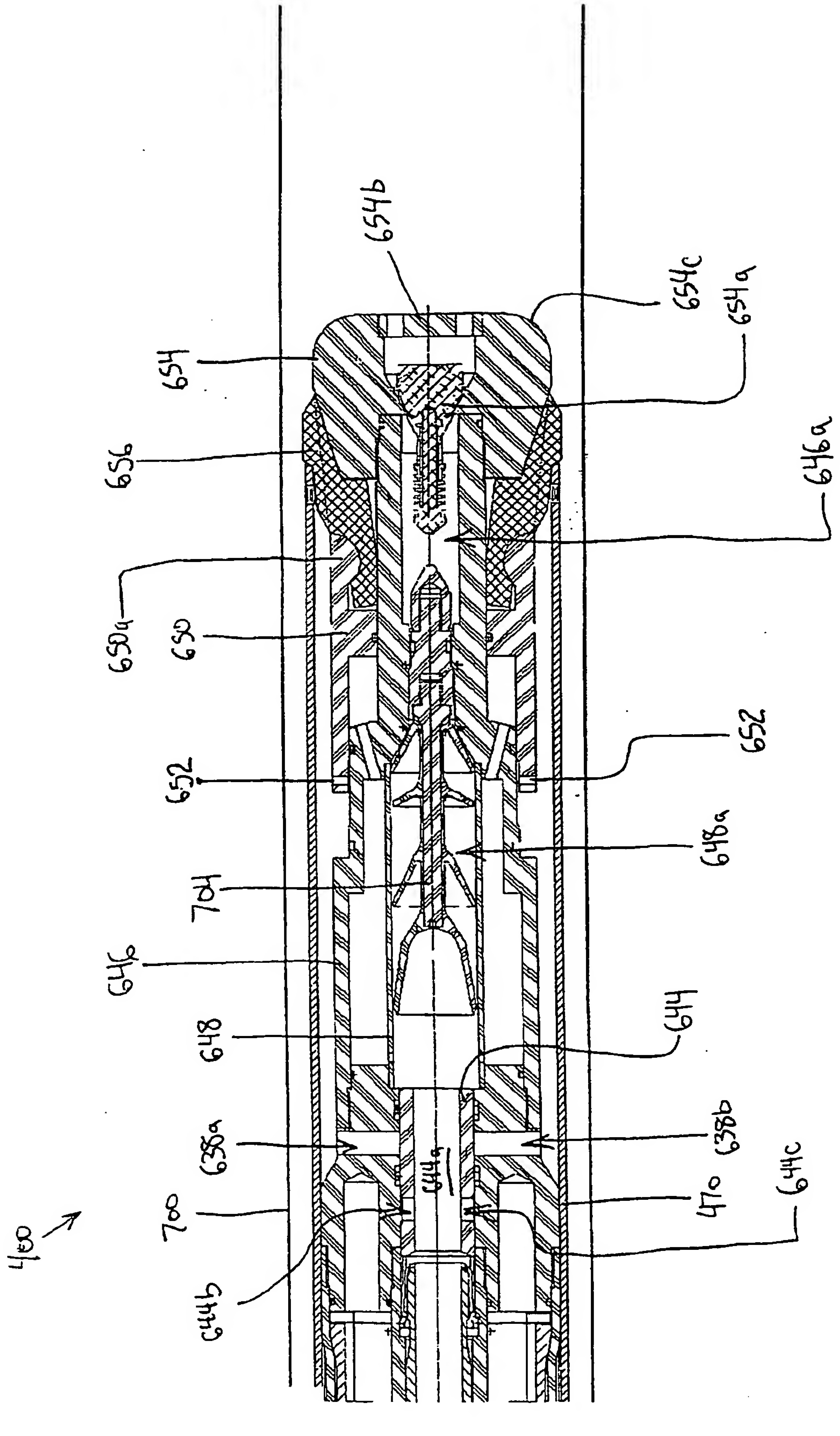

654b
654c
654a
654
656
646a
650a
650
652
652
648a
704
646
648
644
638a
638b
644a
470
644c
700
400
644b

Fig. 29m

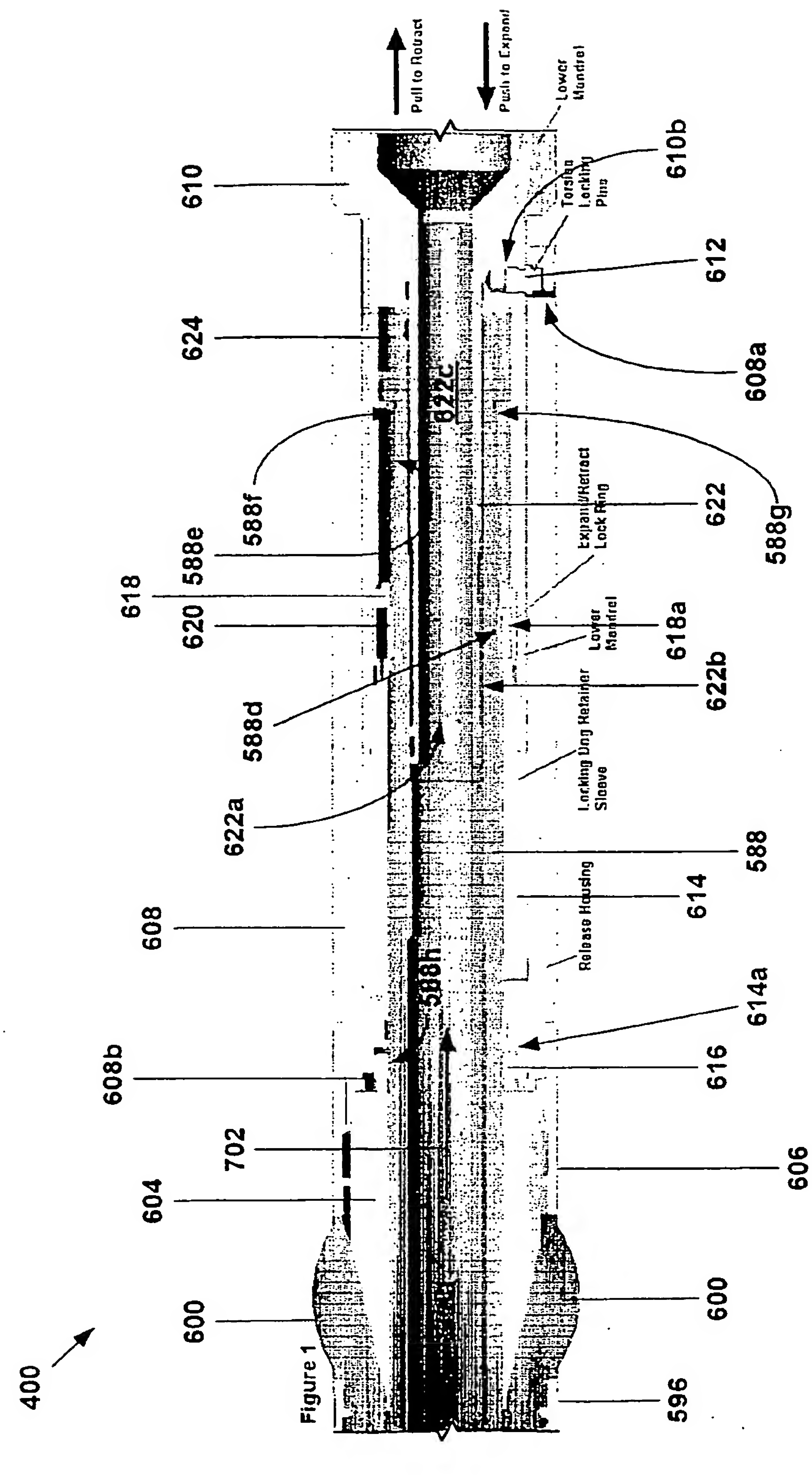

Pull to Retract
Push to Expand
Lower Mandrel
610
610b
Torsion Locking Pins
612
624
608a
622c
588f
588g
588e
622
Expand/Retract Lock Ring
618
620
618a
Lower Mandrel
588d
622b
Locking Dog Retainer Sleeve
622a
588
608
614
Release Housing
588h
614a
608b
616
702
606
604
600
600
400
Figure 1
596

Fig. 30a

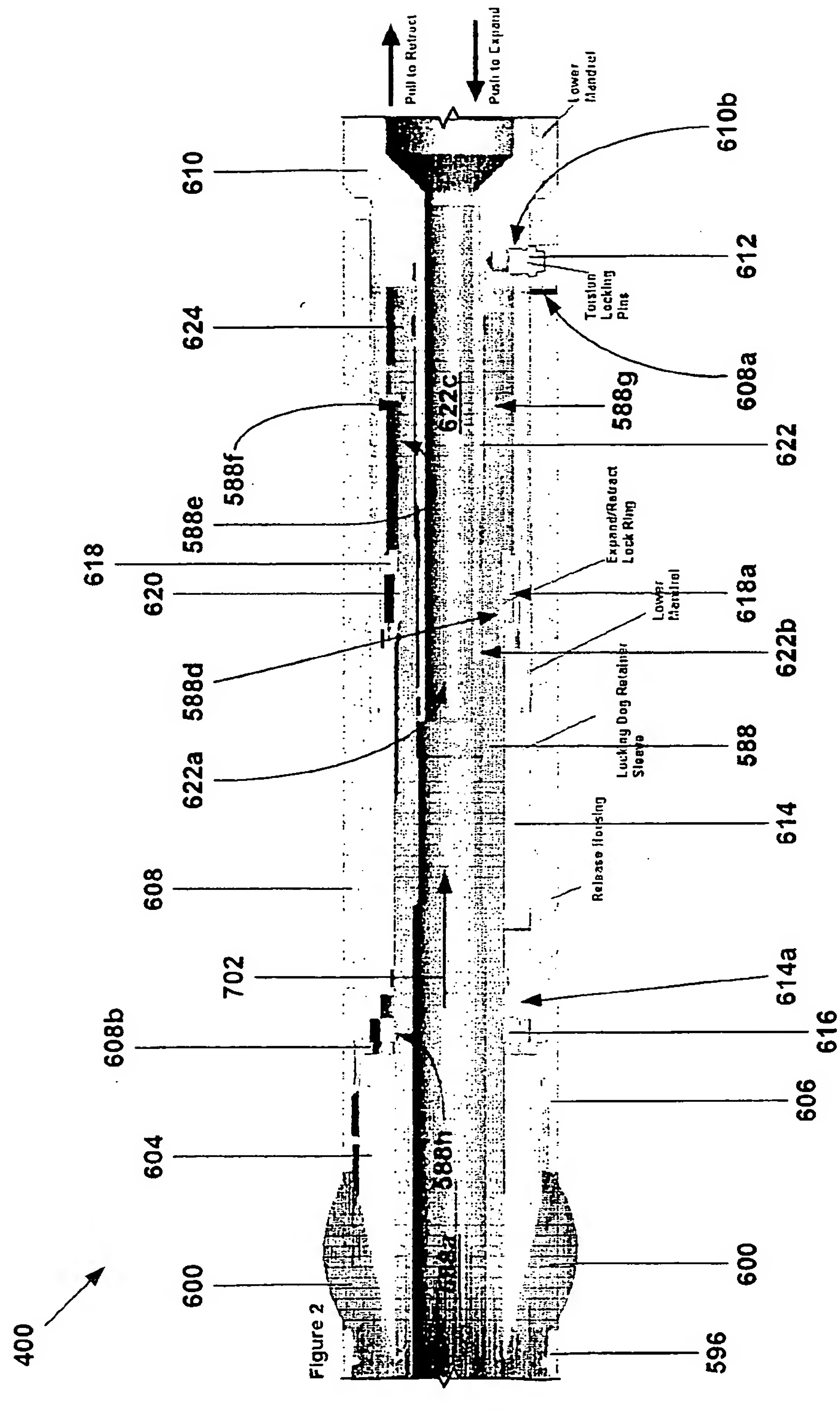

400
600
604
608b
702
608
622a
588d
620
618
588e
588f
624
610
Pull to Retract
Push to Expand
Lower Mandrel
610b
612
Torsion Locking Pins
608a
588g
622c
622
Expand/Retract Lock Ring
618a
Lower Mandrel
622b
Locking Dog Retainer Sleeve
588
614
Release Housing
614a
616
606
600
596
588h
Figure 2

Fig. 30b

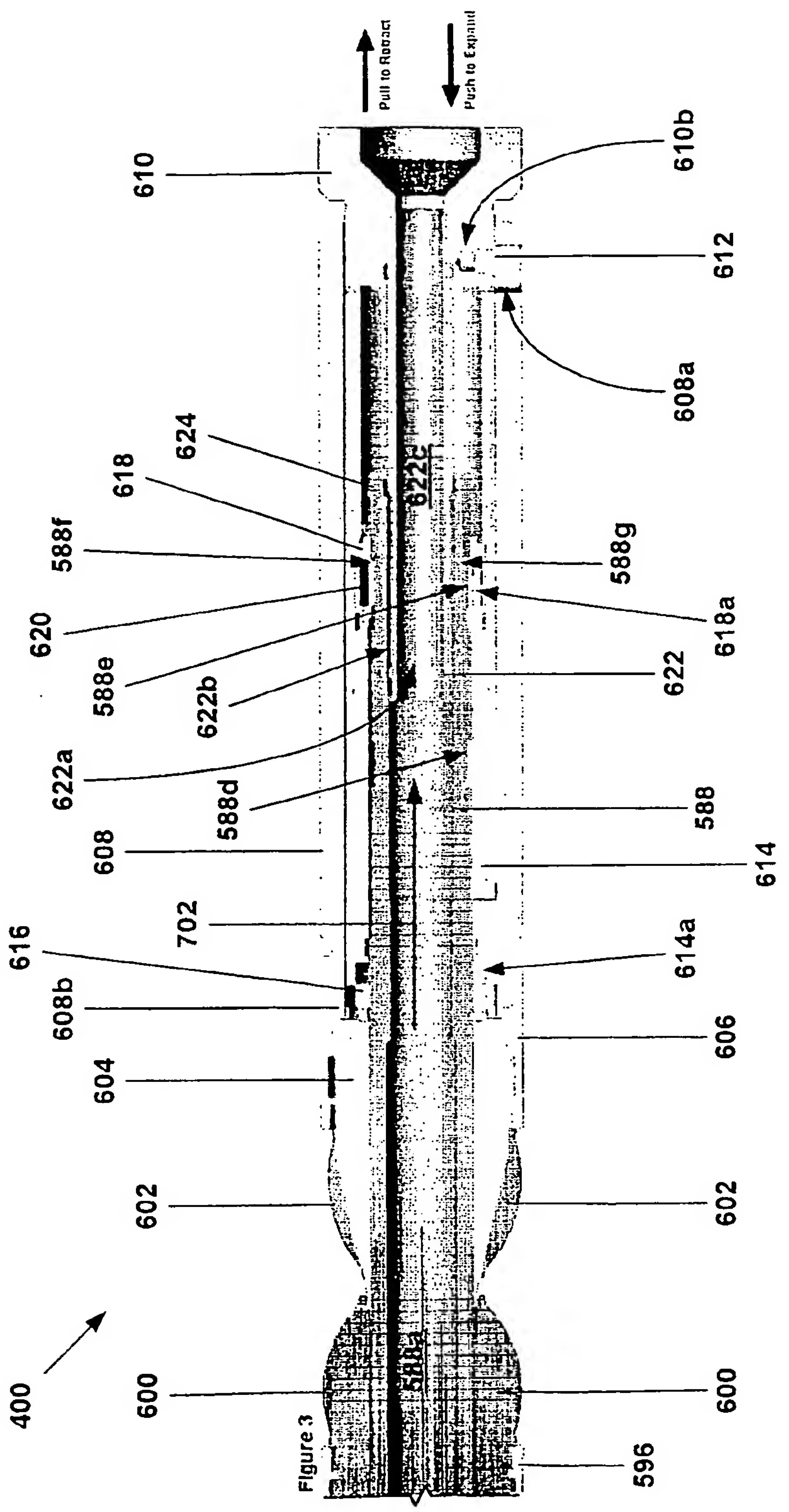

Pull to Retract
Push to Expand
610
610b
612
608a
624
618
588f
620
588e
622b
622a
588d
608
702
616
608b
604
602
600
400
622c
588g
618a
622
588
614
614a
606
596
Figure 3

Fig. 30c

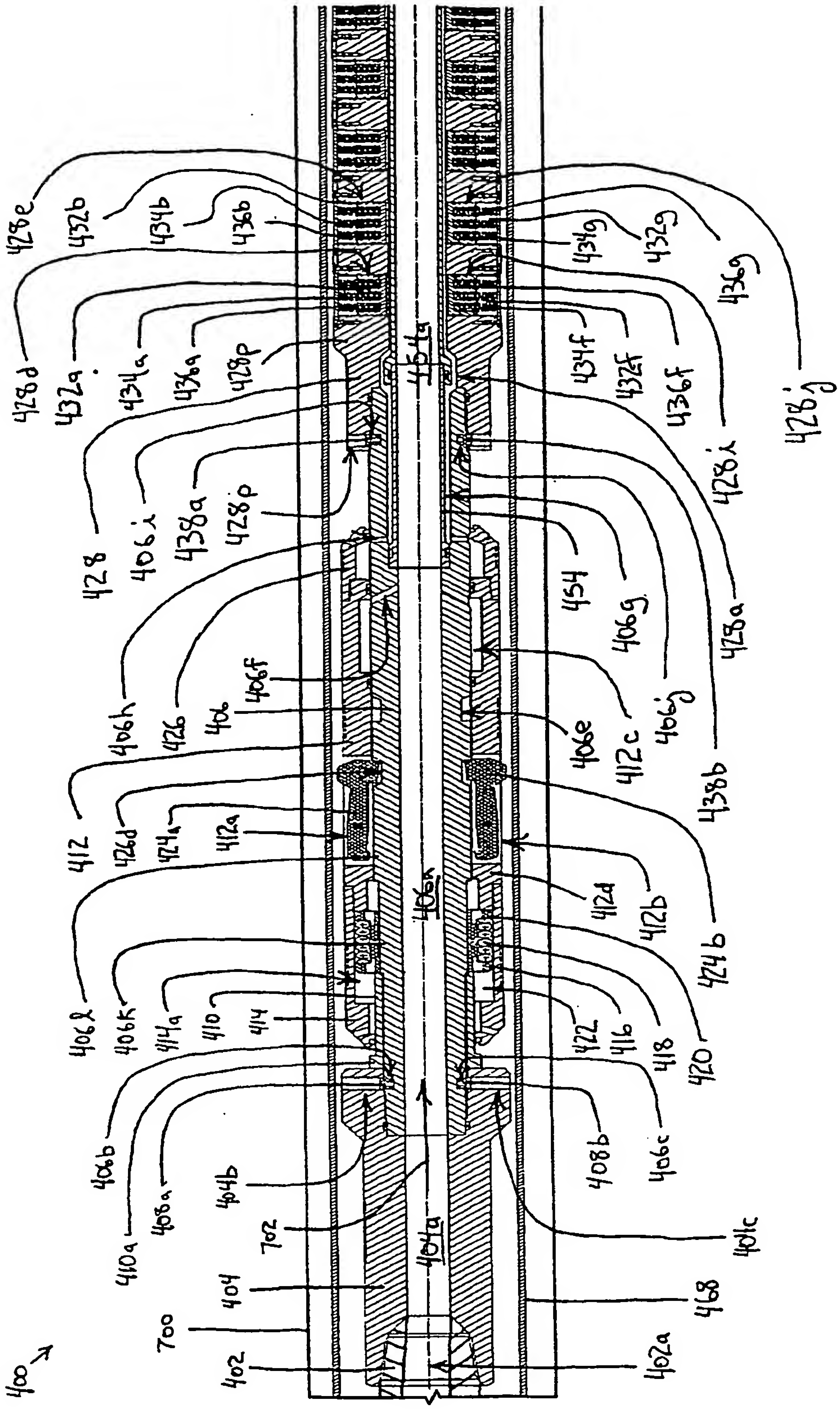

400
700
402
404
702
404a
404b
408a
410a
406b
406l
406k
414a
410
414
412
426d
424a
412a
406h
426
406
406f
428
406i
438a
428p
428d
432a
434a
436a
428e
432b
434b
436b
454a
406k
402a
468
404c
406c
408b
422
416
418
420
424b
412b
412d
438b
412c
406e
406j
406g
454
428a
428i
436f
432f
434f
434g
432g
436g
428j

Fig. 31a

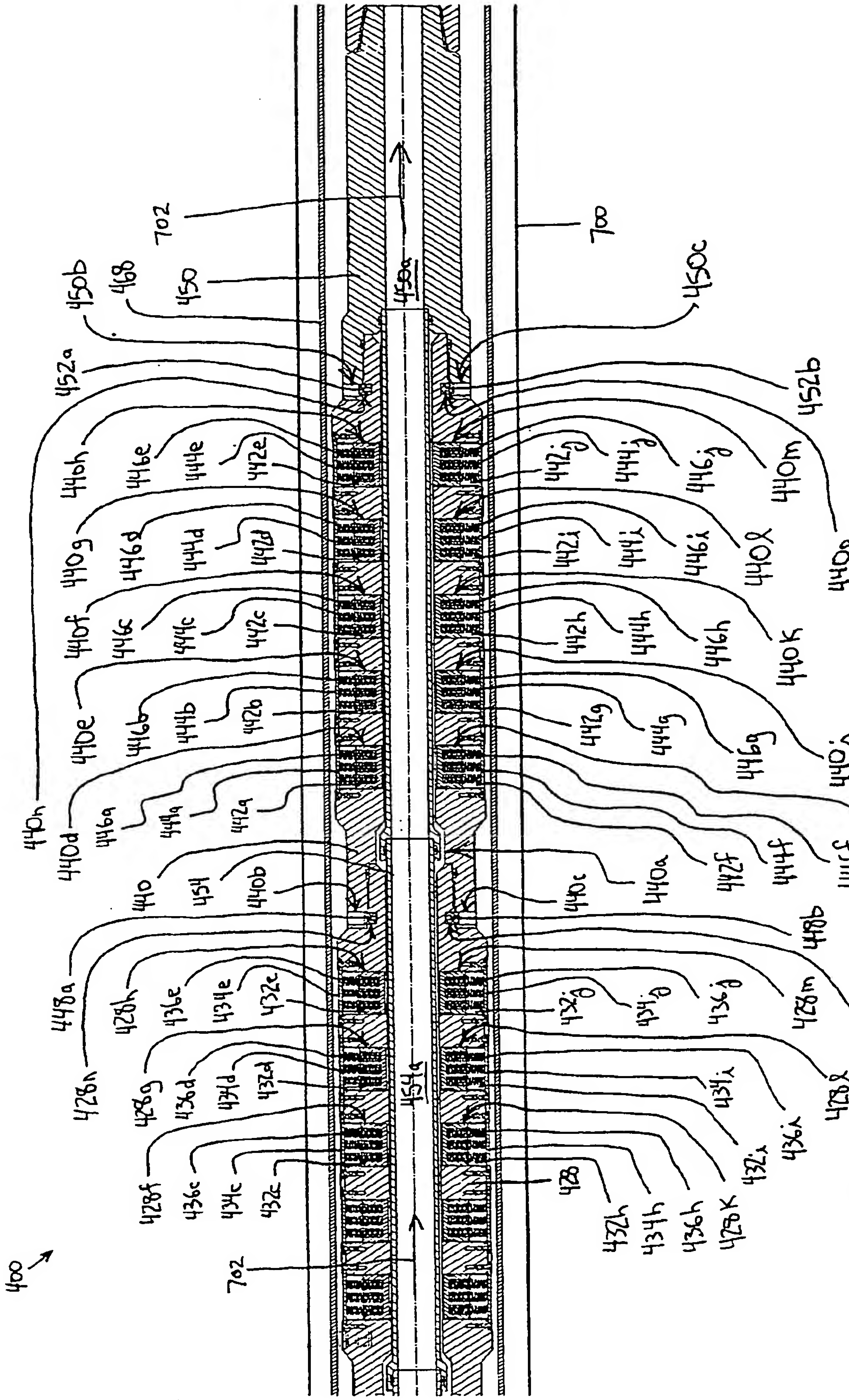

400
702
700
450
450a
450b
450c
468
452a
452b
440
454
454a
440a
440b
440c
448a
448b
428

Fig. 31b

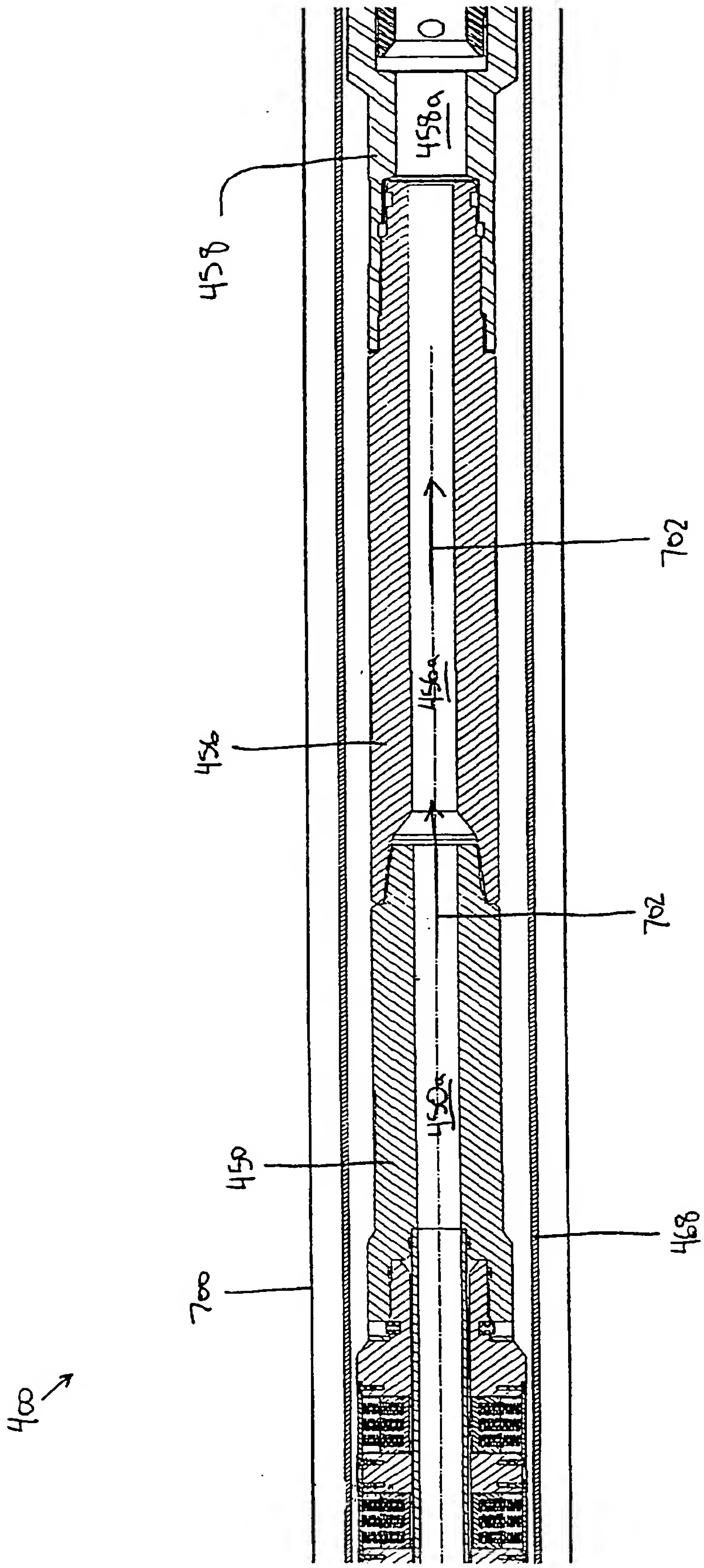


Fig. 31c

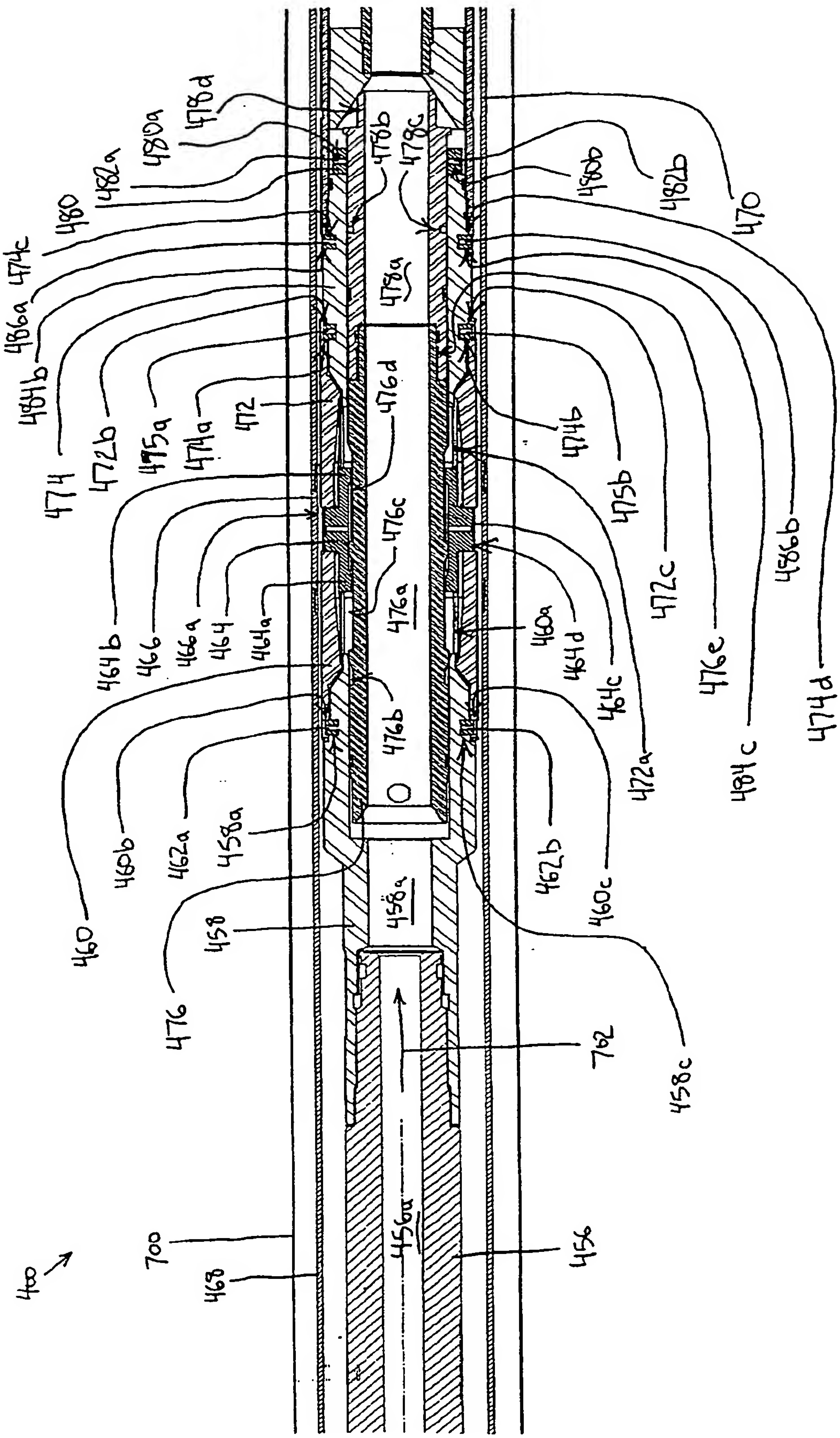

400
700
468
456a
456
762
458
458a
458c
476
460
460b
462a
458a
462b
460c
476b
472a
484c
474d
464b
466
466a
464
464a
476a
460a
464d
464c
476c
476d
476e
472c
486b
474
472b
475a
474a
472
474b
475b
484b
486a
474c
480
482a
480a
478d
478b
478c
478a
480b
482b
470

Fig. 31d

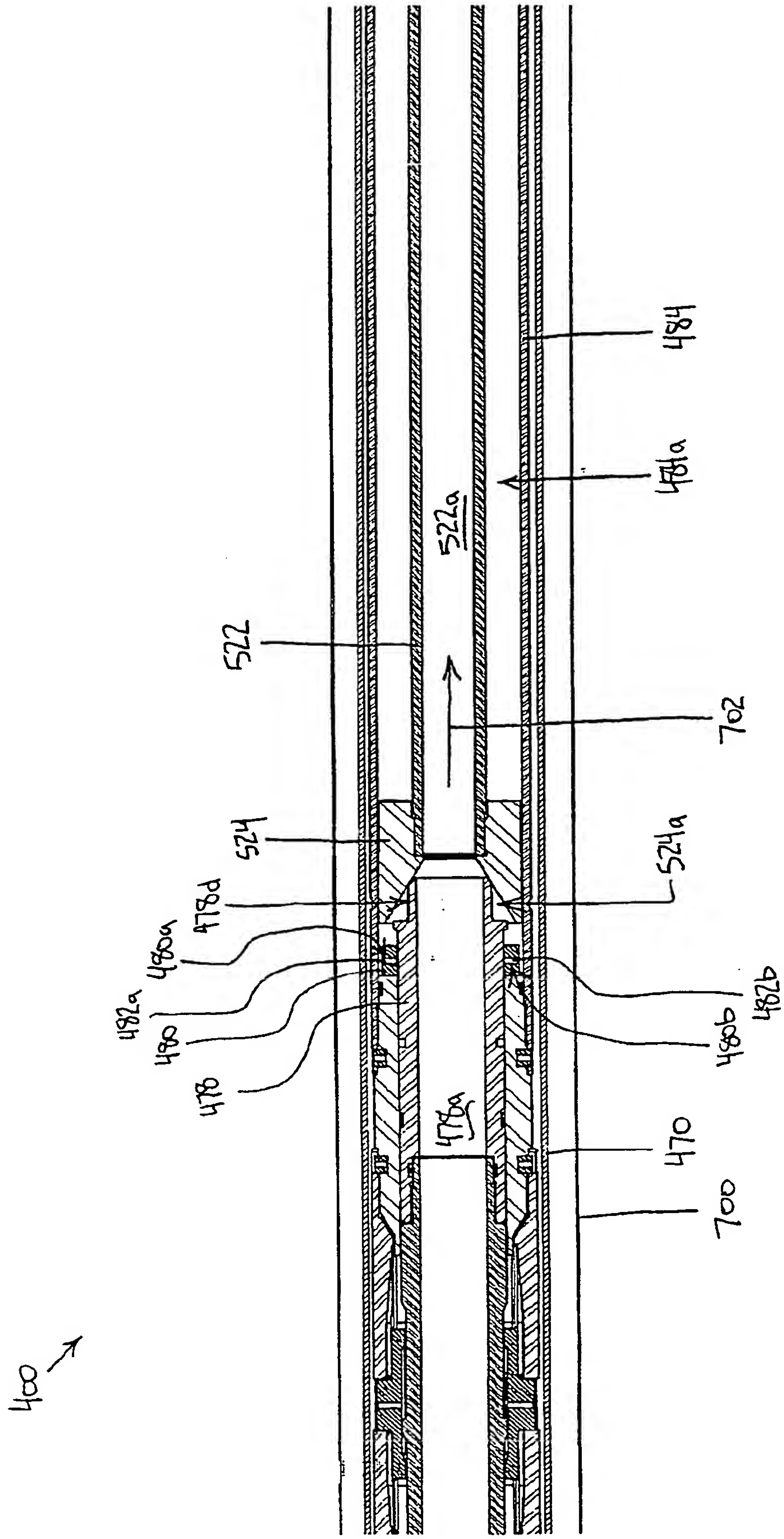

484
484a
522a
522
702
524
524a
478d
480a
482a
490
478
478a
482b
480b
470
700
400

Fig. 31e

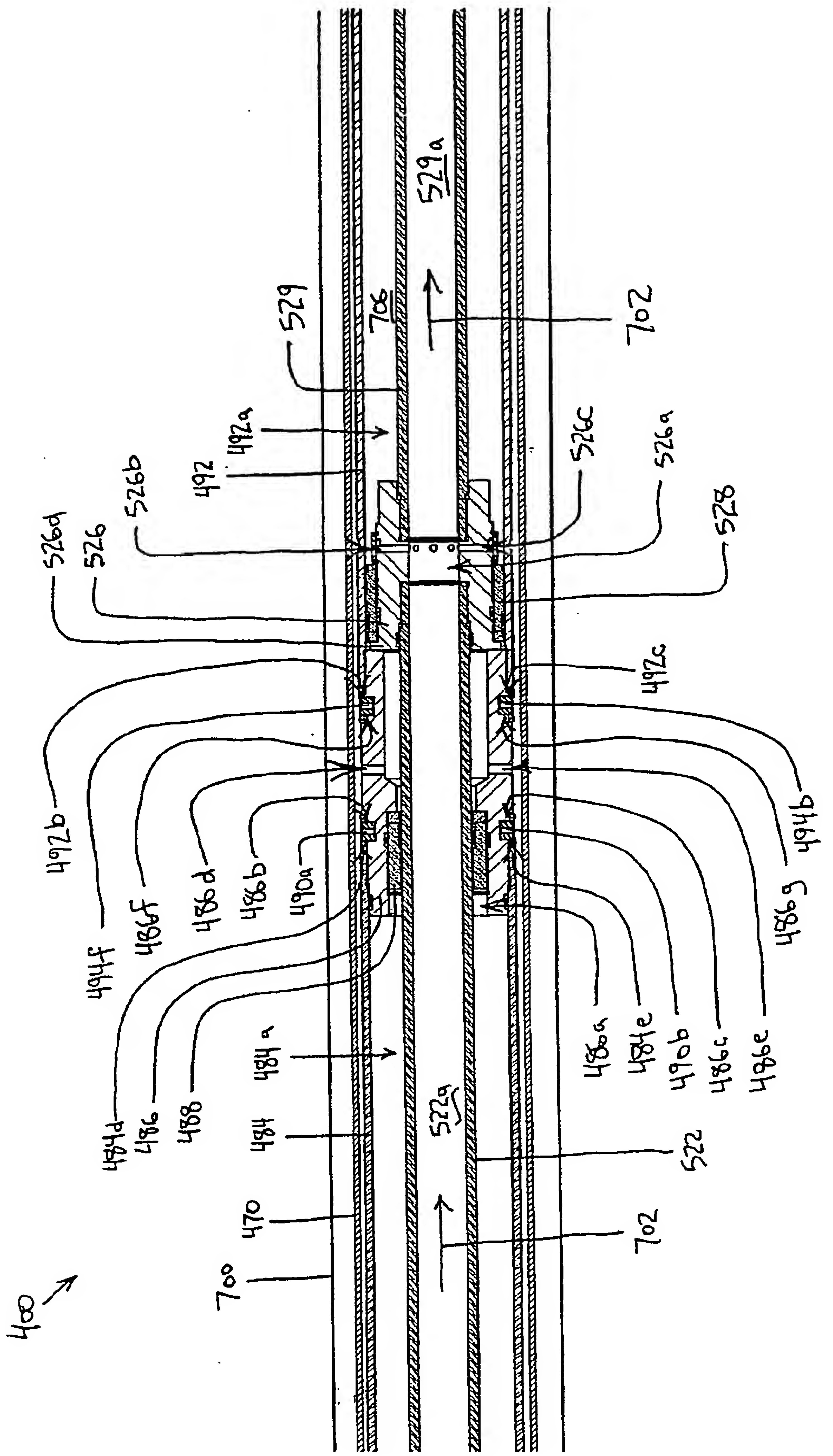
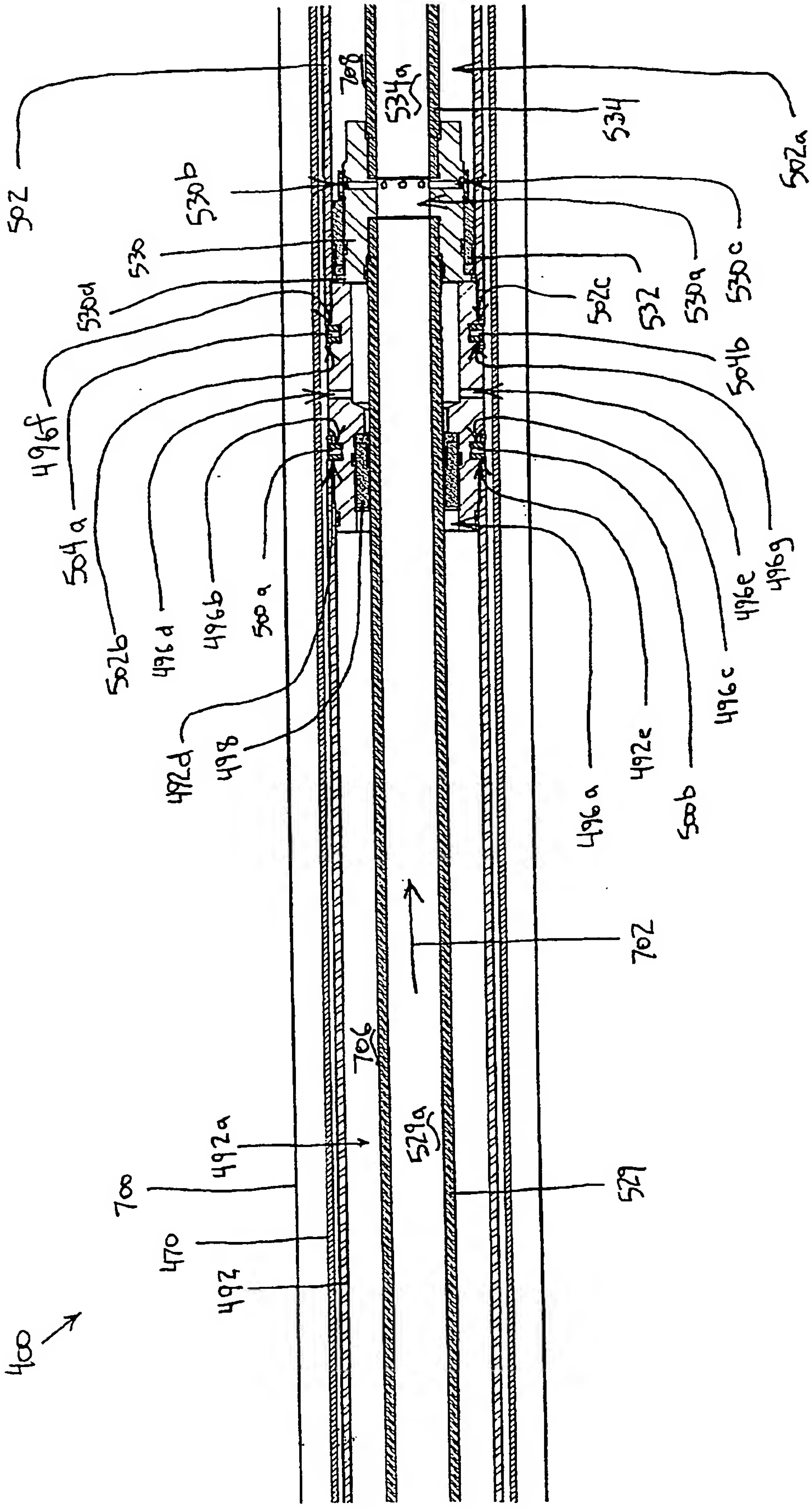

400
700
470
484
484a
522a
522
702
494d
486
488
490a
486b
486d
486f
494f
492b
526d
526
526b
492
492a
529
706
529a
702
526c
526a
528
492c
494b
486g
496b
486e
486c
490b
484e
486a

Fig. 31f



400
700
470
492
492a
529a
529
706
702
492d
498
496a
492e
500b
502b
496d
496b
500a
496c
504a
496f
496e
496g
530d
504b
530
502c
532
530a
530c
530b
502
502a
534
534a
708

Fig. 31g

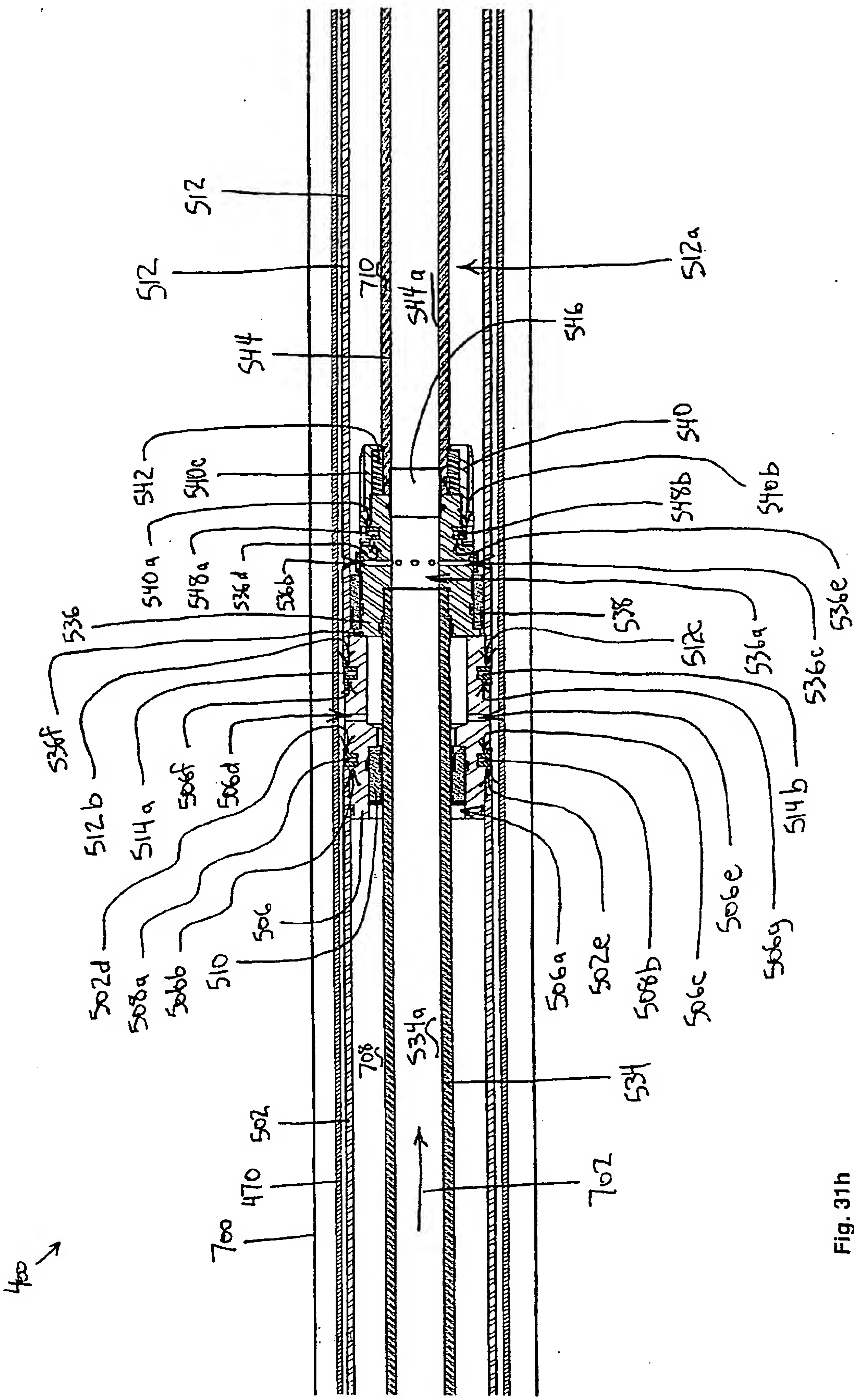


Fig. 31h

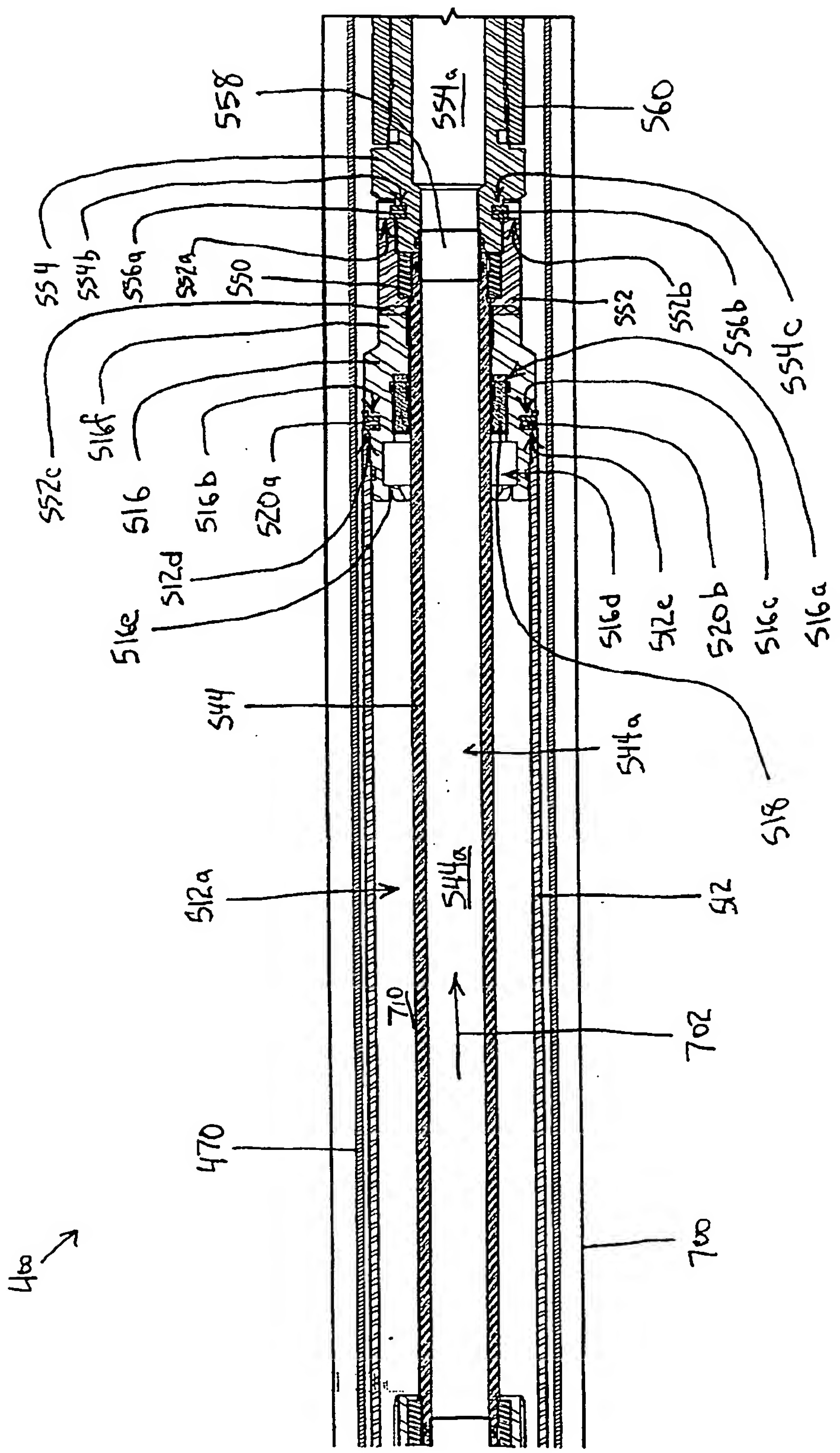

558
554a
560
554
554b
556a
552a
550
552
552b
556b
554c
552c
516f
516
516b
520a
512d
516e
516d
512e
520b
516c
516a
544
544a
518
512a
544a
512
710
702
470
400
700

Fig. 31i

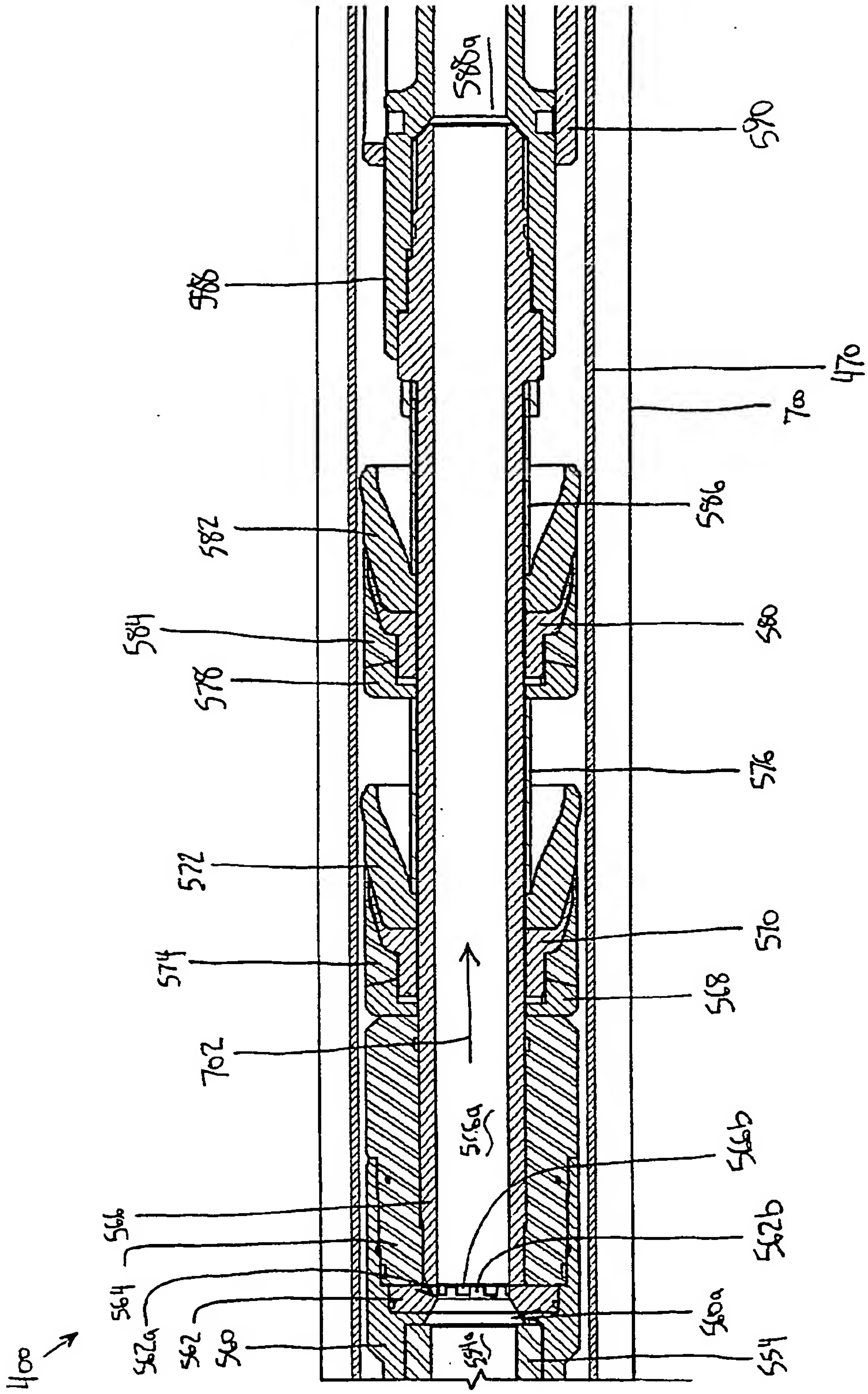

588a
590
588
470
700
586
582
580
584
578
576
572
570
574
568
702
556a
566b
566
562b
564
562
560a
562a
560
554
554a
400

Fig. 31J

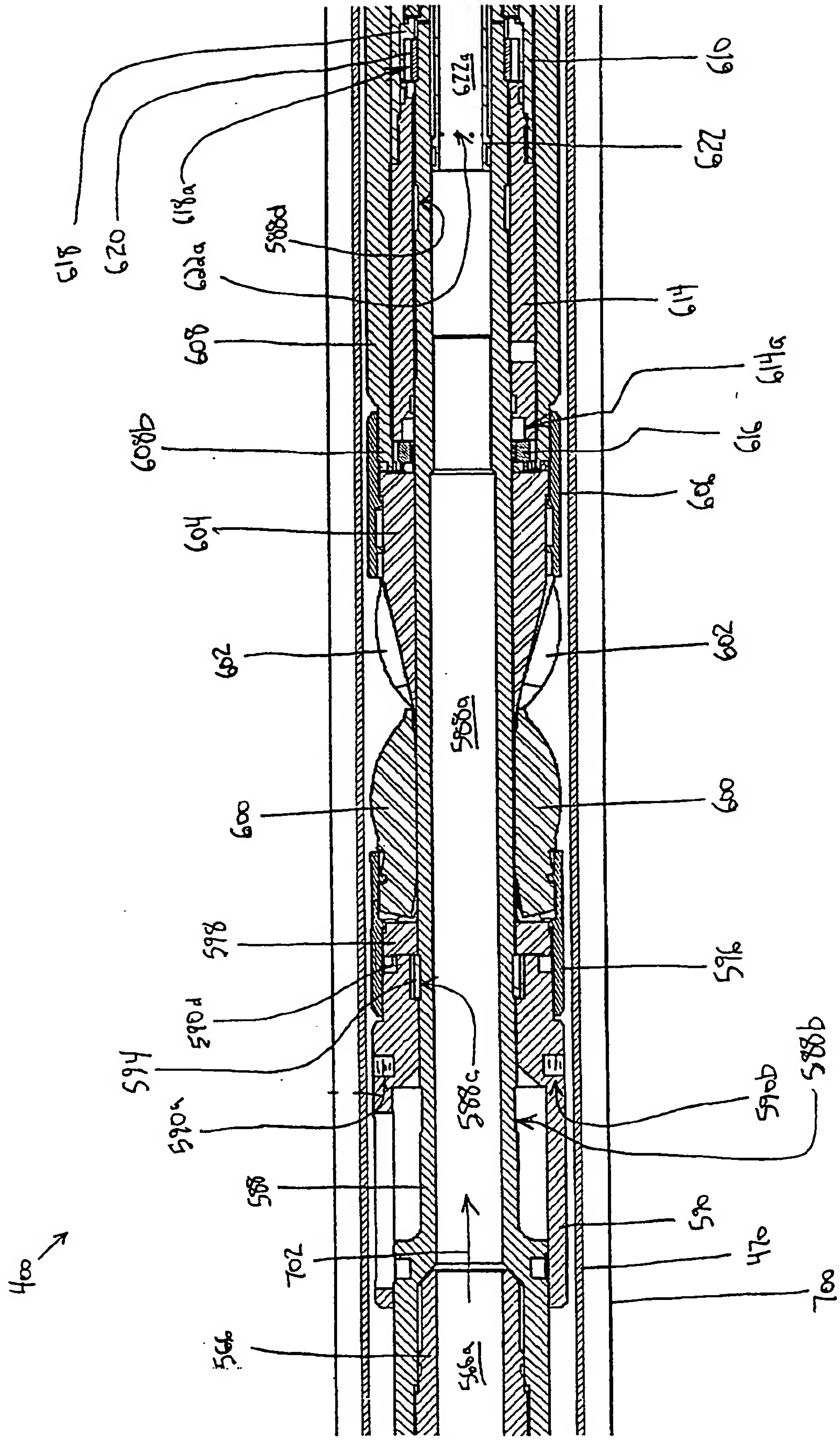
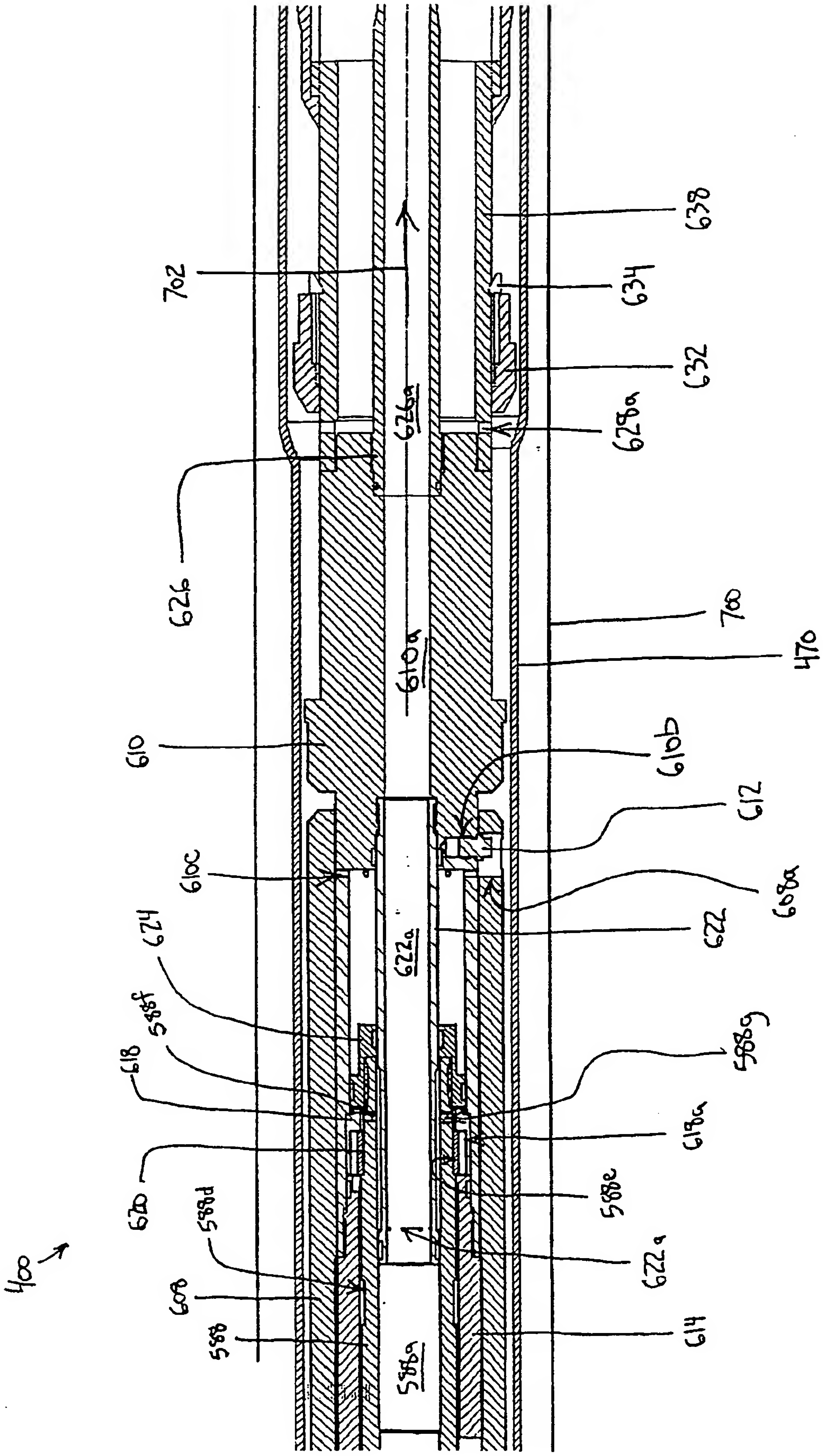

400
618
620
618a
622a
588d
608
608b
604
602
600
598
590d
594
590a
588
702
566
566a
588a
588c
622
622a
610
614
614a
616
606
596
590b
588b
590
470
700

Fig. 31k



638
702
634
632
628a
626a
626
700
470
610a
610
610b
612
610c
608a
622
622a
624
588f
618
588g
618a
620
588e
588d
622a
400
608
588
588a
614

Fig. 31I

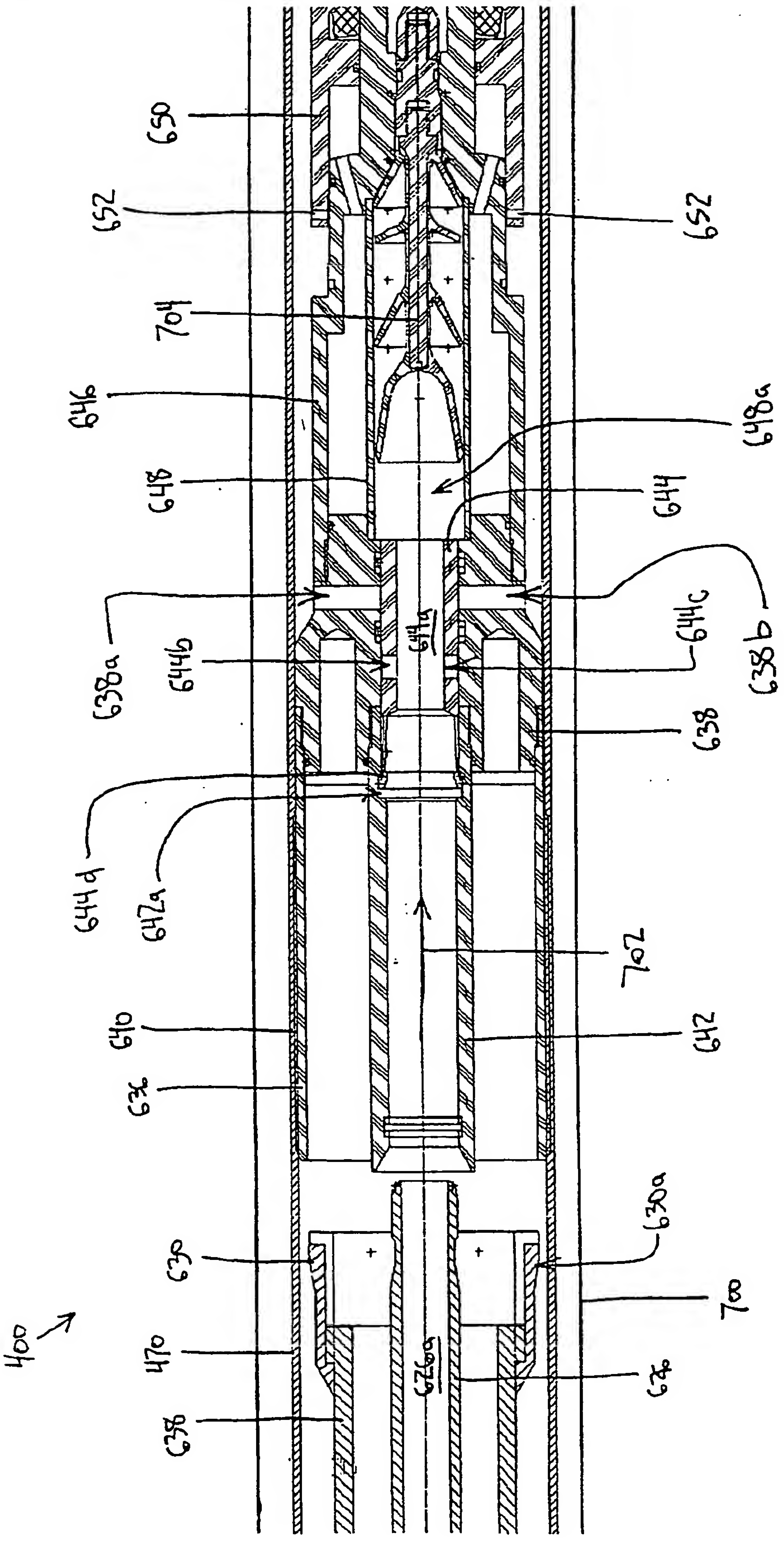

650
652
652
704
646
648a
648
644
638a
644b
644a
644c
638b
638
644d
642a
702
640
642
636
630a
630
700
400
470
626a
626
638

Fig. 31m

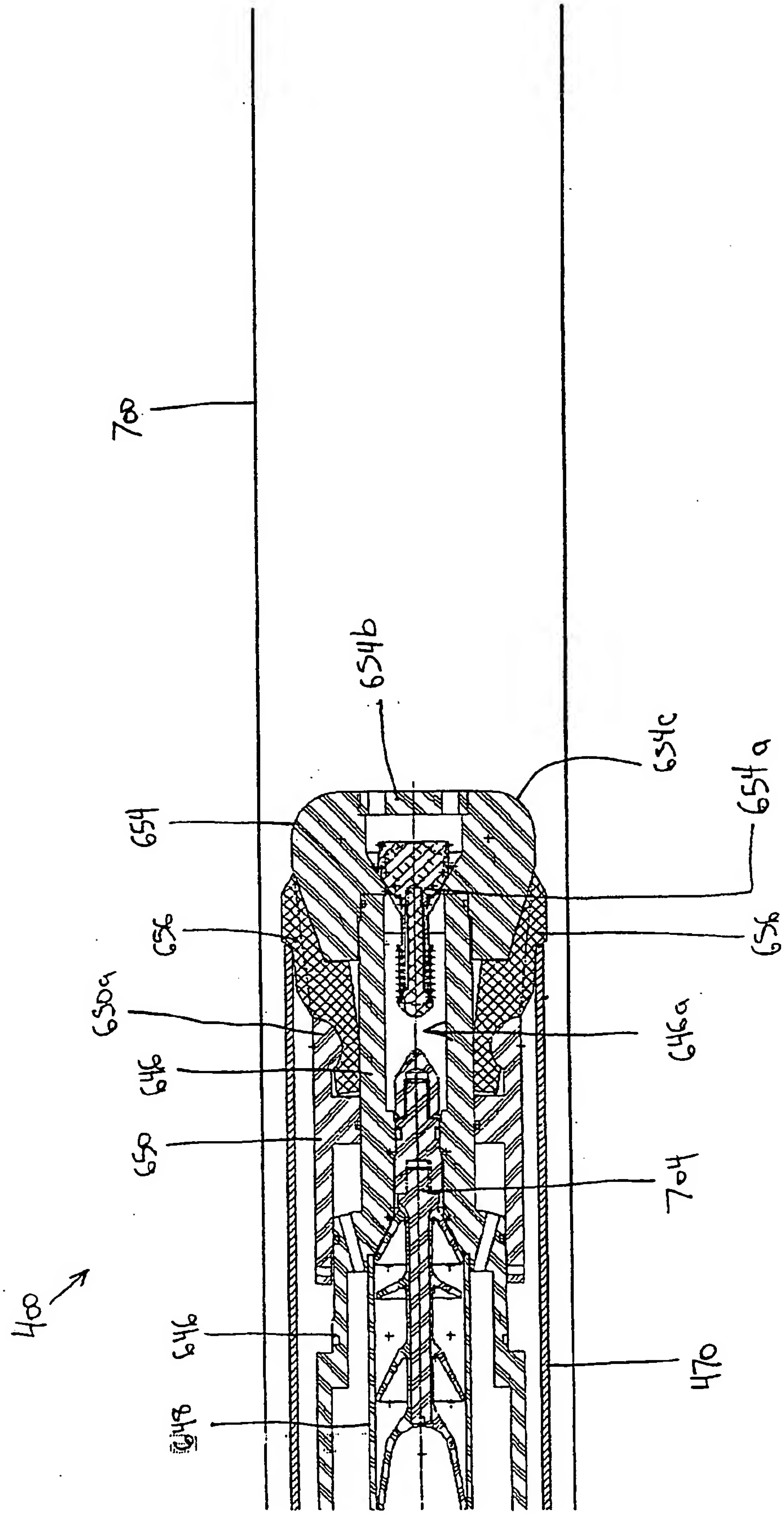

700
654b
654c
654a
654
656
656
650a
646a
646
650
704
400
646
470
648

Fig. 31n

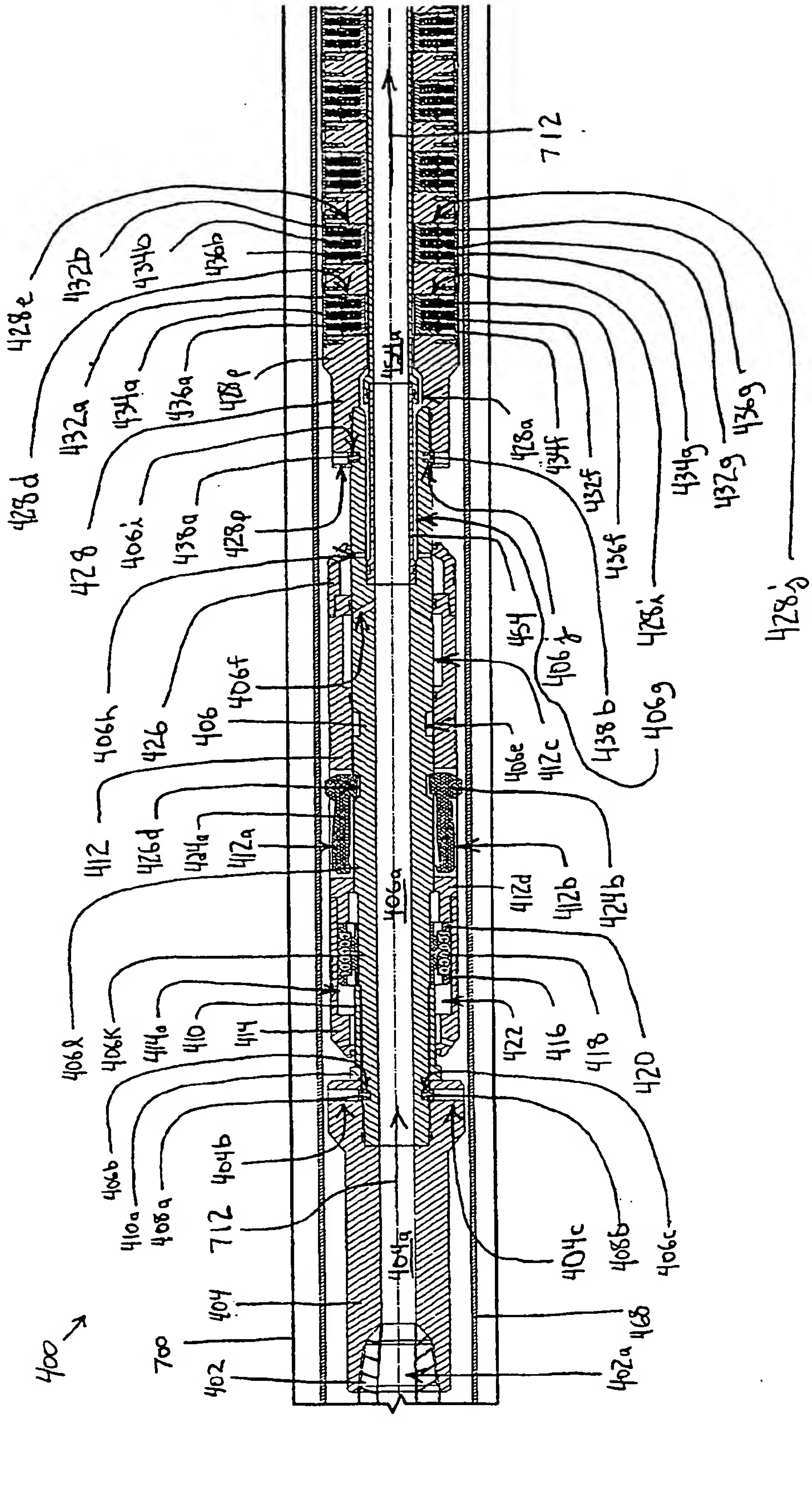

400
700
402
404
712
404a
404b
408a
410a
406b
406l
406k
414a
410
414
412a
424a
426d
412
406
426
406h
406f
428p
438a
406i
428
436a
434a
432a
428d
428f
436b
434b
432b
428e
454a
406a
712
428a
434f
432f
436f
428i
434g
432g
436g
428j
454
406j
438b
406g
406e
412c
412d
412b
424b
422
416
418
420
404c
408b
406c
468
402a

Fig. 32a

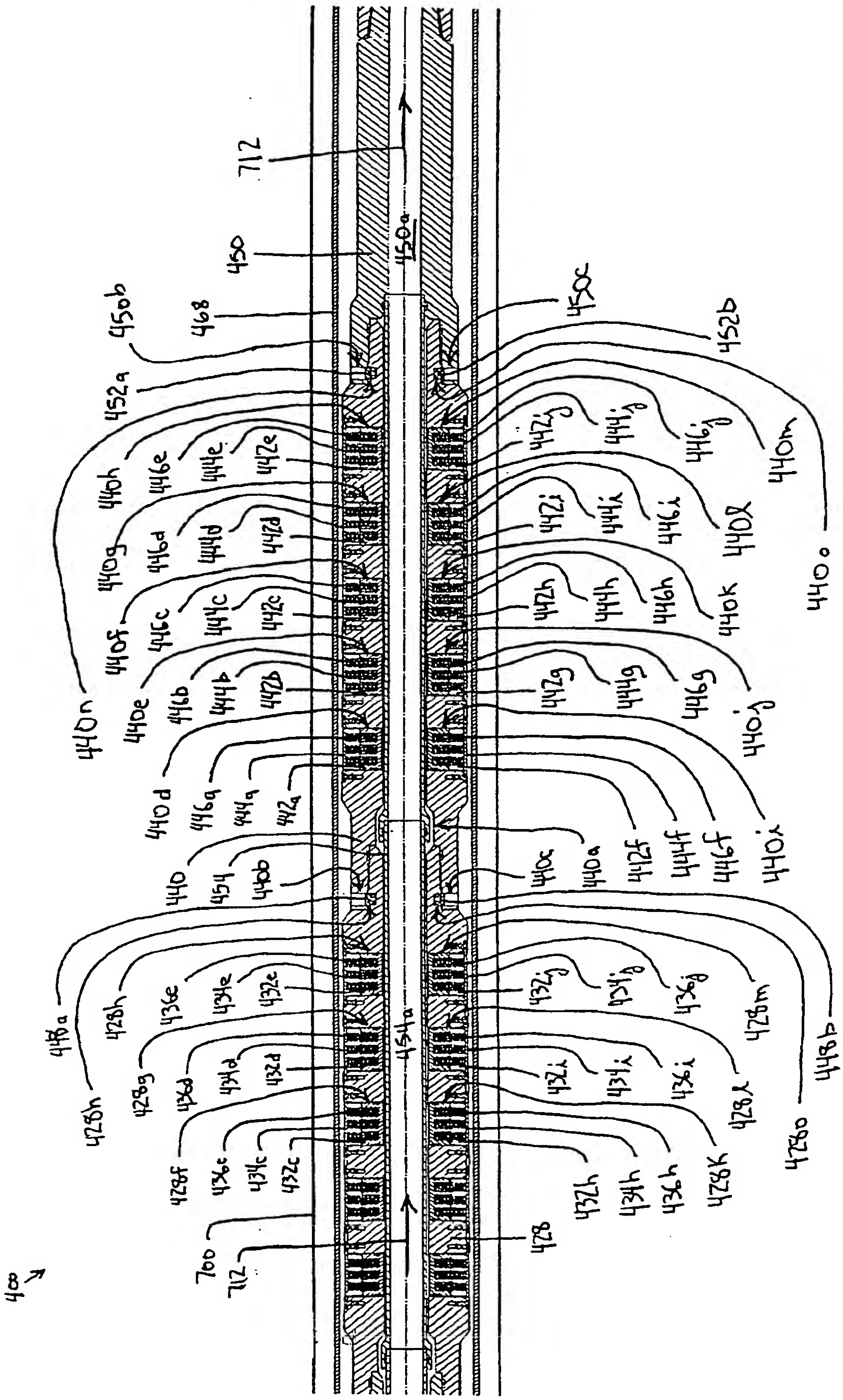

48
712
700
450
450a
450b
450c
468
452a
452b
440
440a
440b
440c
440d
440e
440f
440g
440h
440i
440j
440k
440l
440m
440n
440o
442a
442b
442c
442d
442e
442f
442g
442h
442i
442j
444a
444b
444c
444d
444e
444f
444g
444h
444i
444j
446a
446b
446c
446d
446e
446f
446g
446h
446i
446j
454
454a
448a
448b
428
428f
428g
428h
428i
428j
428k
428m
428n
428o
432c
432d
432e
432h
432i
432j
434c
434d
434e
434h
434i
434j
436c
436d
436e
436h
436i
436j

Fig. 32b

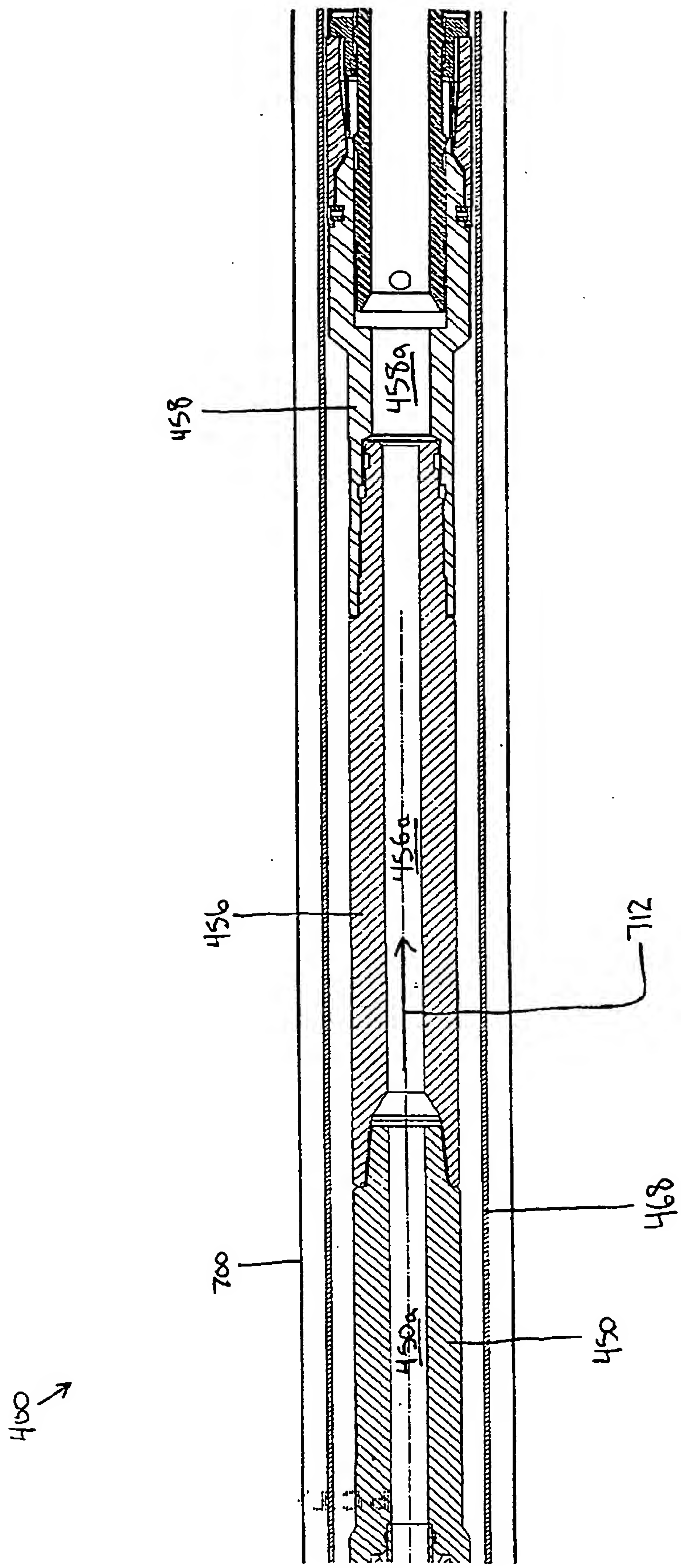


Fig. 32c

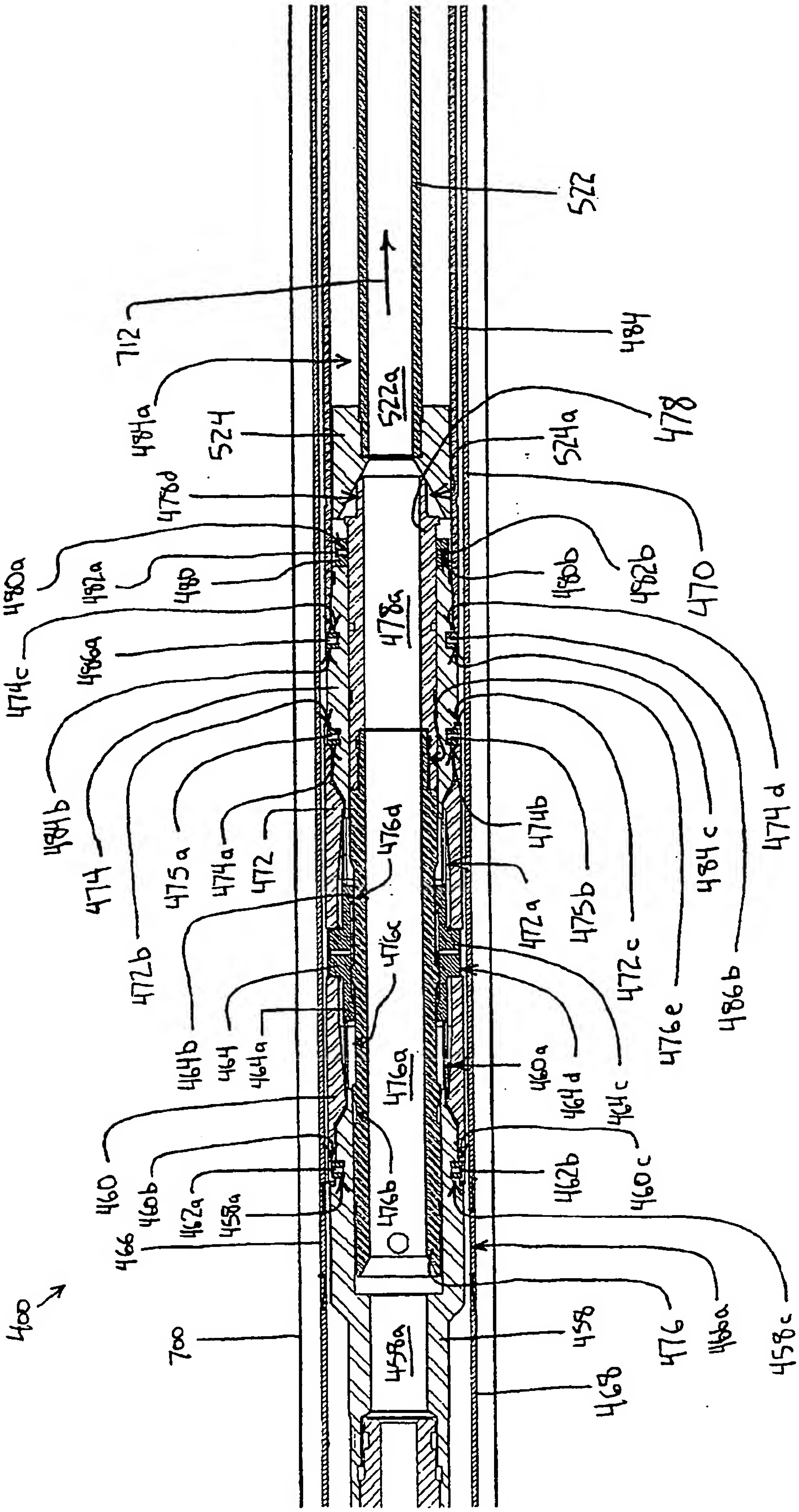

522
712
484
484a
524
522a
524a
478
478d
470
480a
482a
480
480b
482b
474c
486a
478a
474d
484b
474
472b
475a
474a
472
476d
474b
472a
475b
472c
484c
486b
476e
464b
464
464a
476c
476a
460a
464d
464c
460
460b
462a
458a
476b
462b
460c
466
400
700
458a
458
468
476
466a
458c

Fig. 32d

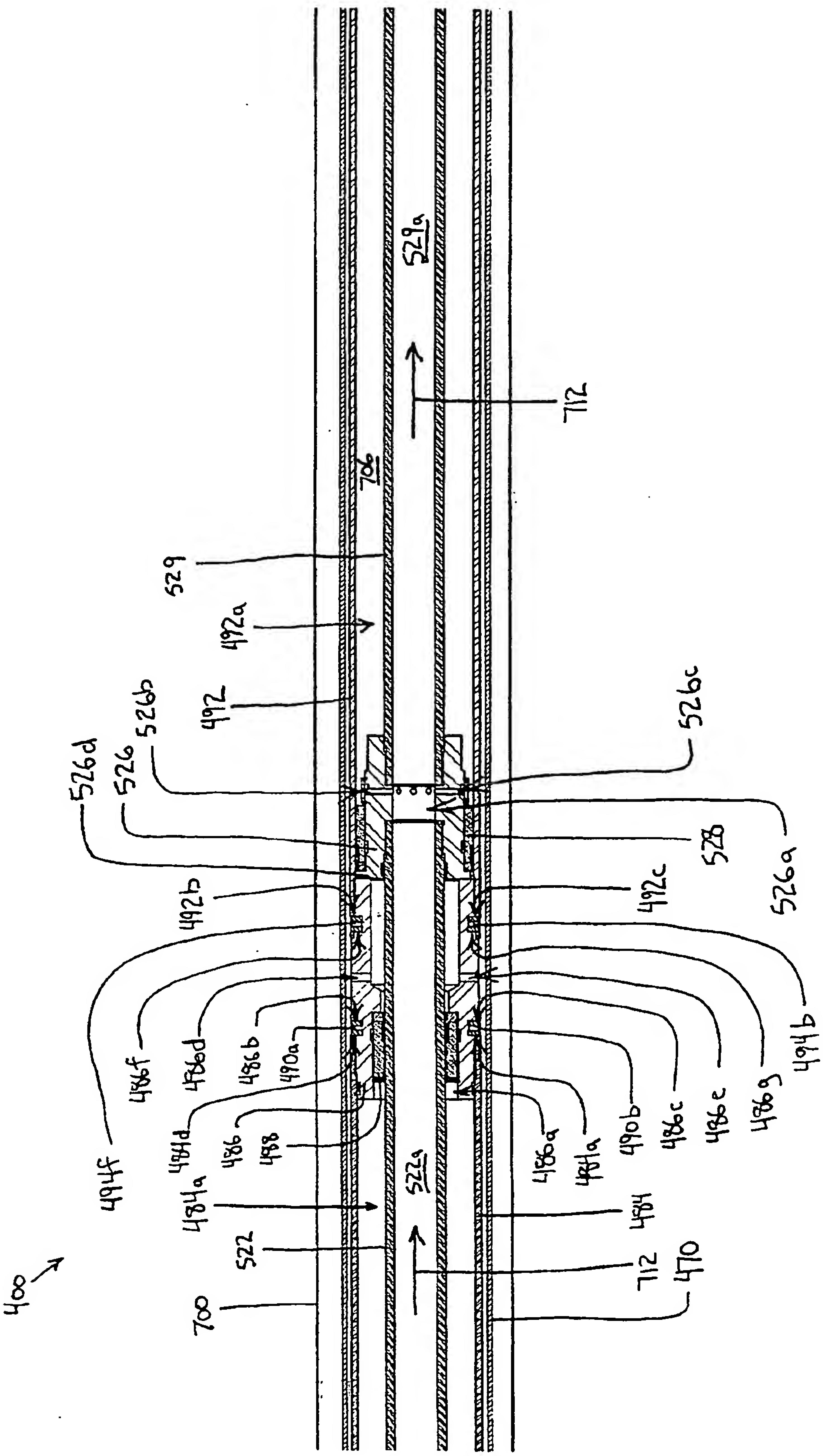

400
700
522
484a
488
486
484d
490a
486b
486d
486f
494f
492b
526d
526
526b
492
492a
529
706
712
529a
526c
528
526a
492c
494b
486g
486e
486c
490b
484a
486a
484
712
470
522a

Fig. 32e

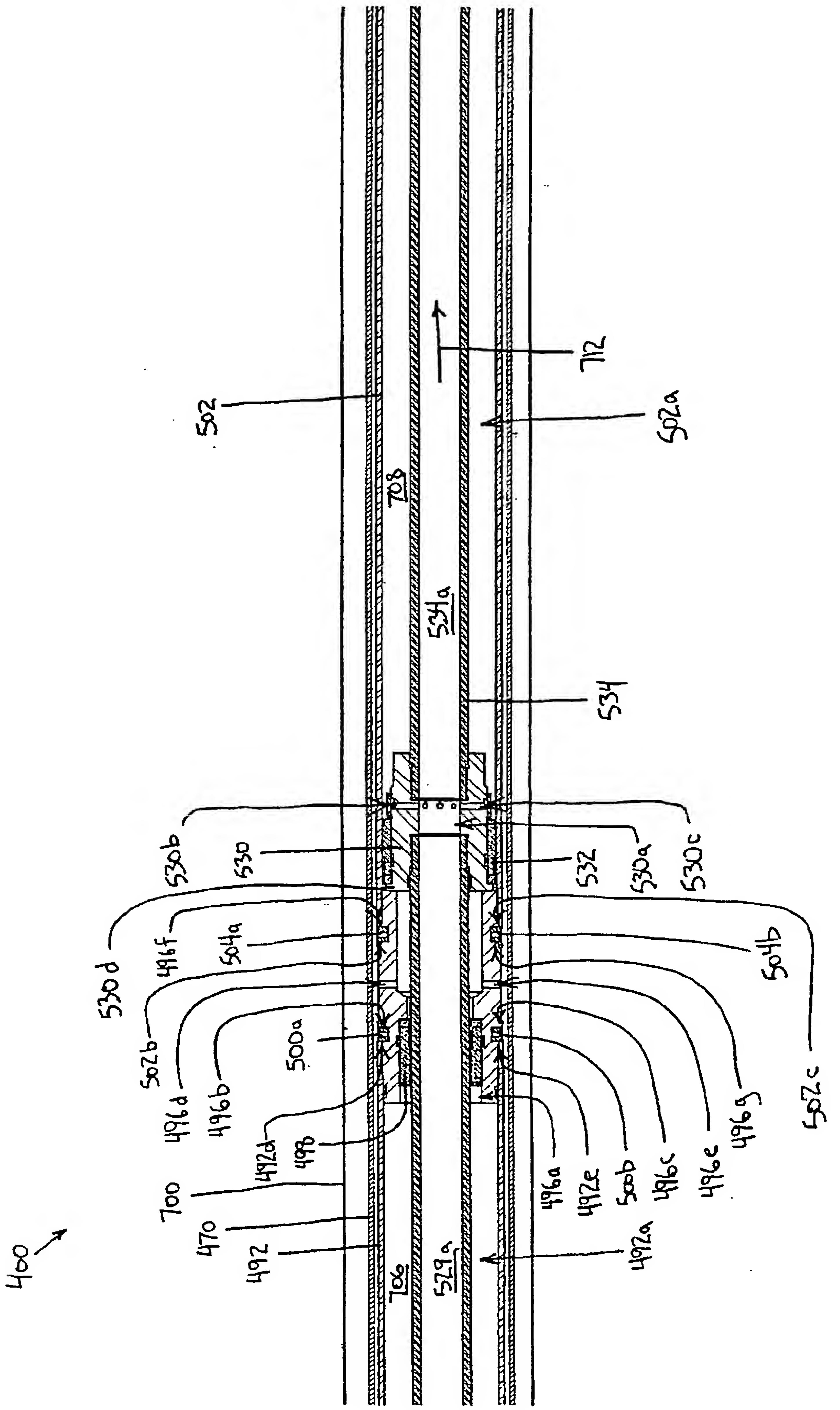

400
502
712
502a
708
534a
534
530b
530
532
530a
530c
530d
496f
504a
504b
502b
496d
496b
500a
492d
498
700
470
492
706
529a
492a
496a
492e
500b
496c
496e
496g
502c

Fig. 32f

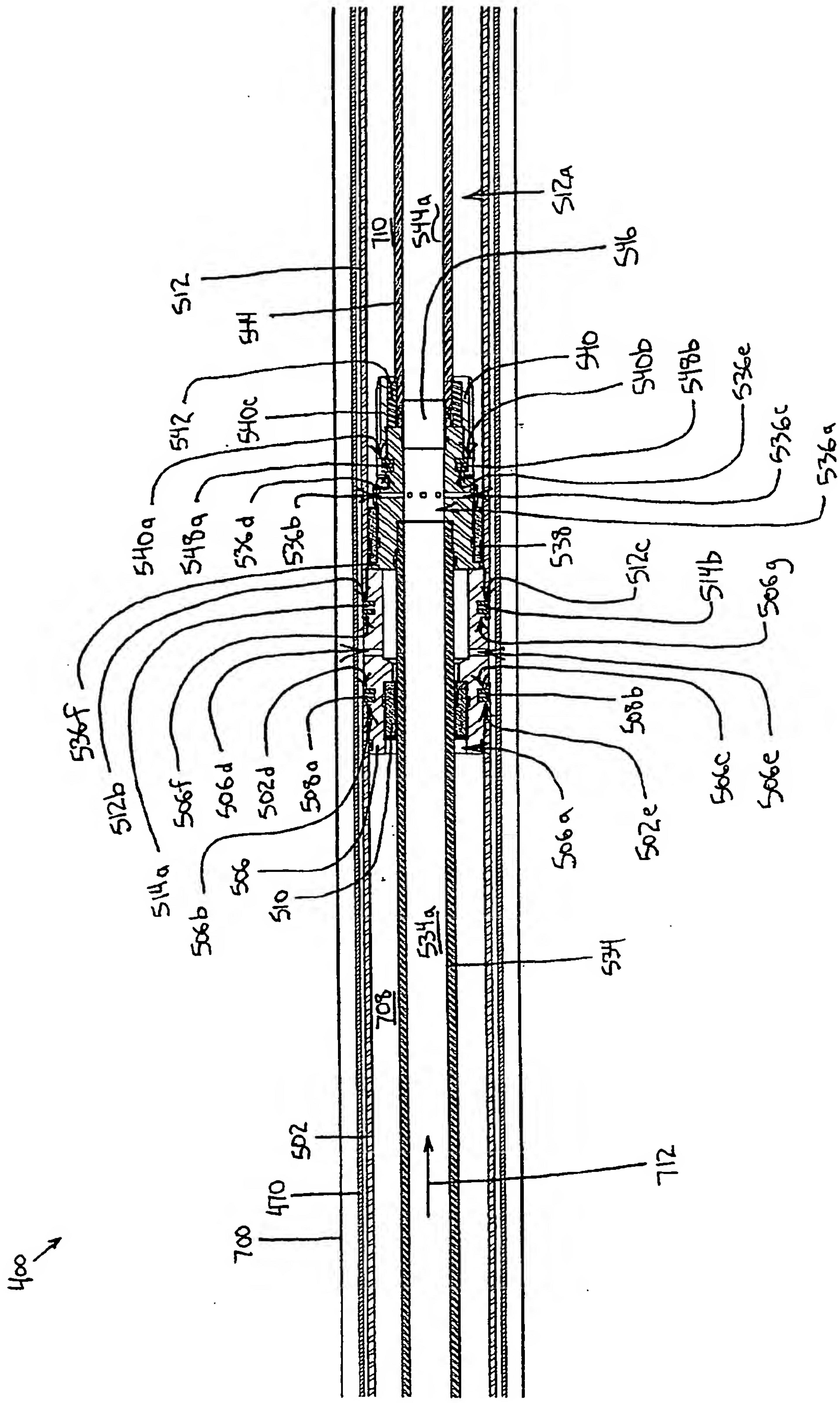
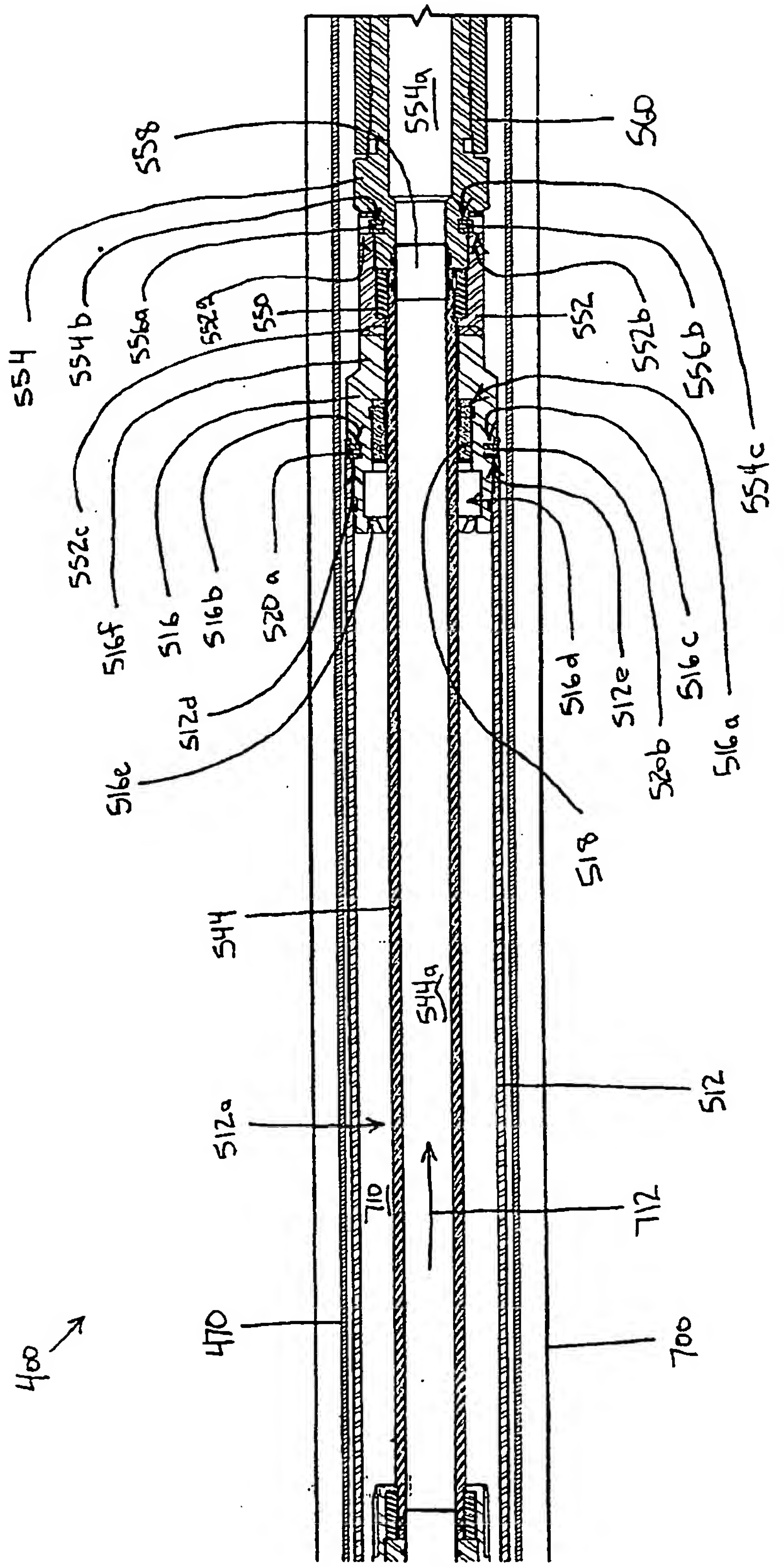

400
700
470
502
712
708
534a
534
510
506
506b
514a
512b
536f
506f
506d
502d
508a
506a
502e
506c
506e
508b
506g
514b
512c
538
536b
536d
548a
540a
536a
536c
536e
548b
540b
540c
542
540
544
512
710
544a
546
512a

Fig. 32g



554
554b
556a
552a
550
558
554a
560
552
552b
556b
554c
552c
516f
516
516b
520a
512d
516e
516d
512e
520b
516c
516a
518
544
544a
512a
710
712
512
470
700
400

Fig. 32h

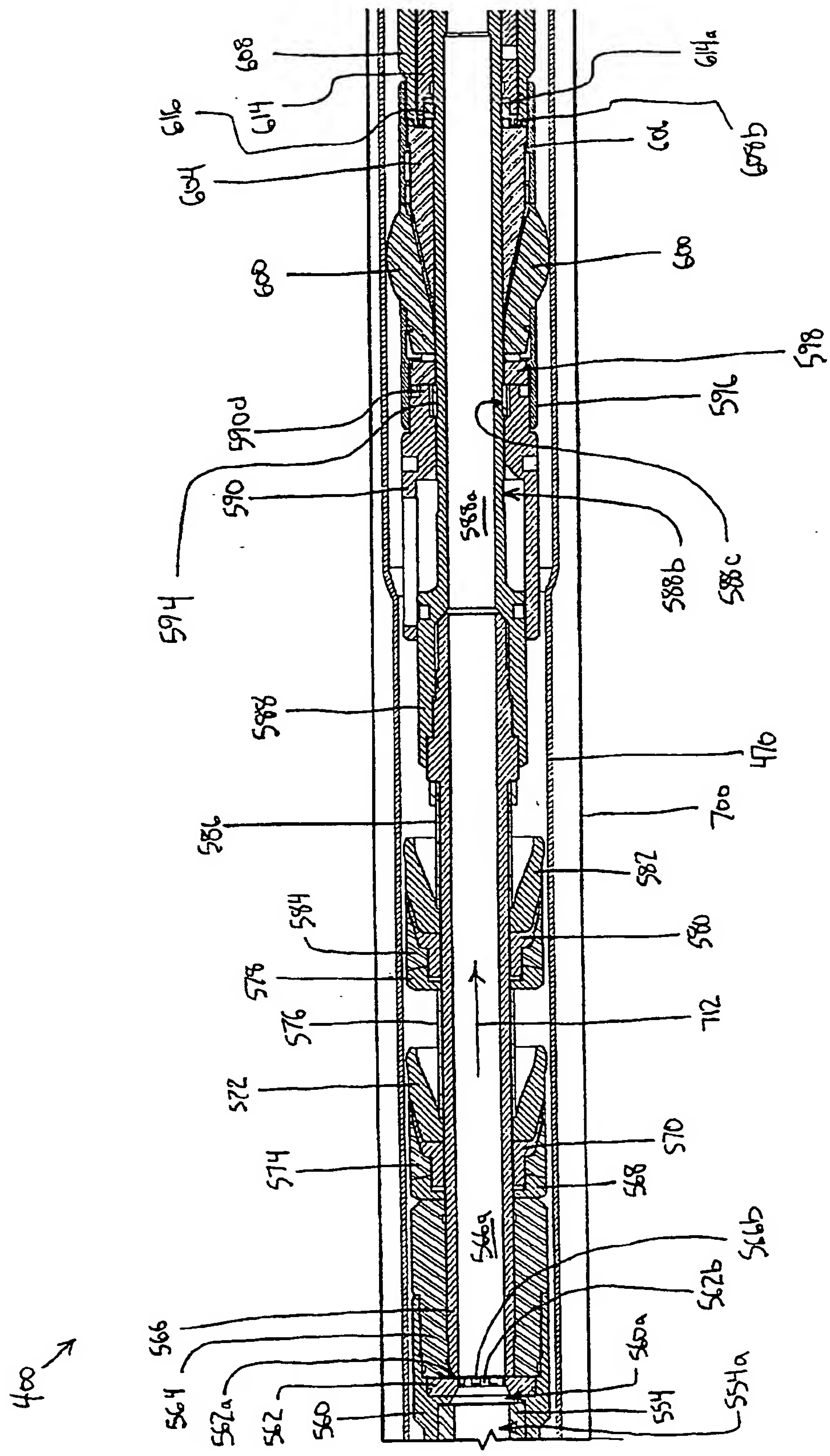

400
608
614
616
604
614a
608b
606
600
600
598
596
590d
594
590
588a
588b
588c
588
470
700
586
582
580
584
578
576
712
572
570
574
568
566a
566b
562b
566
564
562a
560a
562
554
560
554a

Fig. 32I

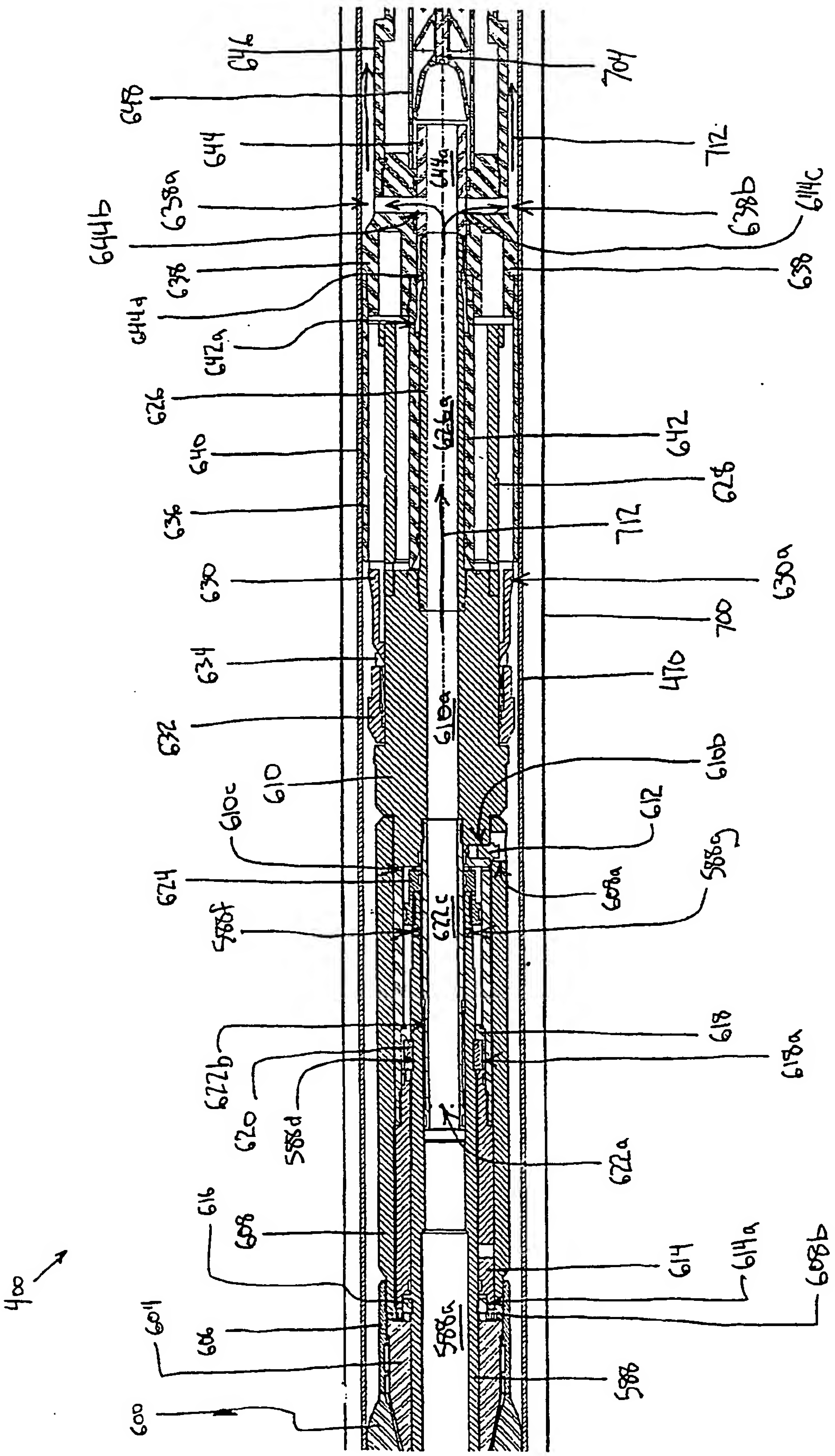

646
648
644
638a
644b
638
644a
642a
626
640
636
630
634
632
610
610c
624
588f
622b
620
588d
616
608
606
604
600
400
704
712
644a
638b
644c
638
642
628
712
630a
700
470
616b
612
588g
608a
588e
618
618a
622a
614
614a
608b
588
618a
626a
622c
588a

Fig. 32J

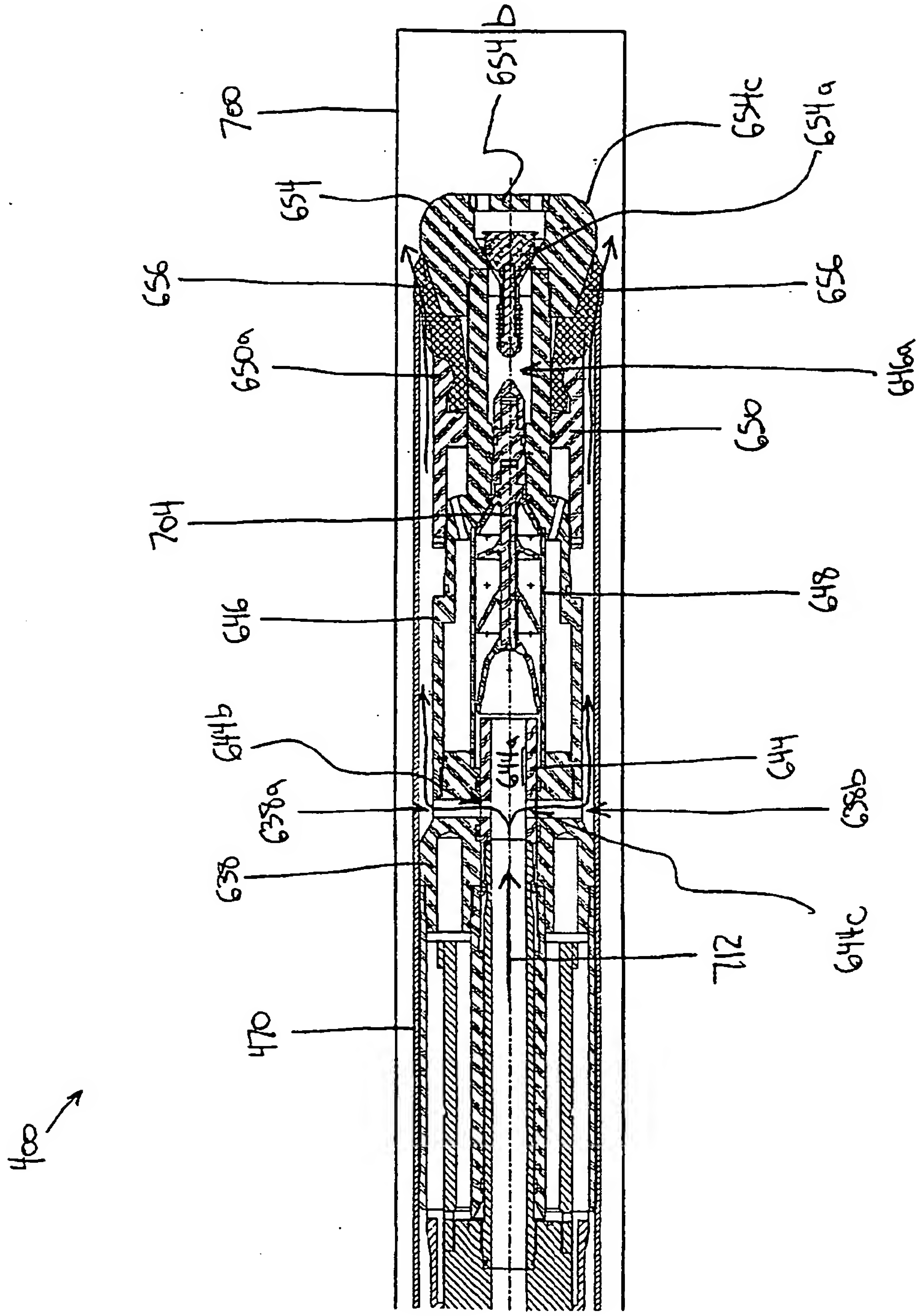

700
654b
654c
654a
654
656
656
650a
646a
650
704
648
646
644b
644a
644
638a
638b
638
644c
712
470
400

Fig. 32k

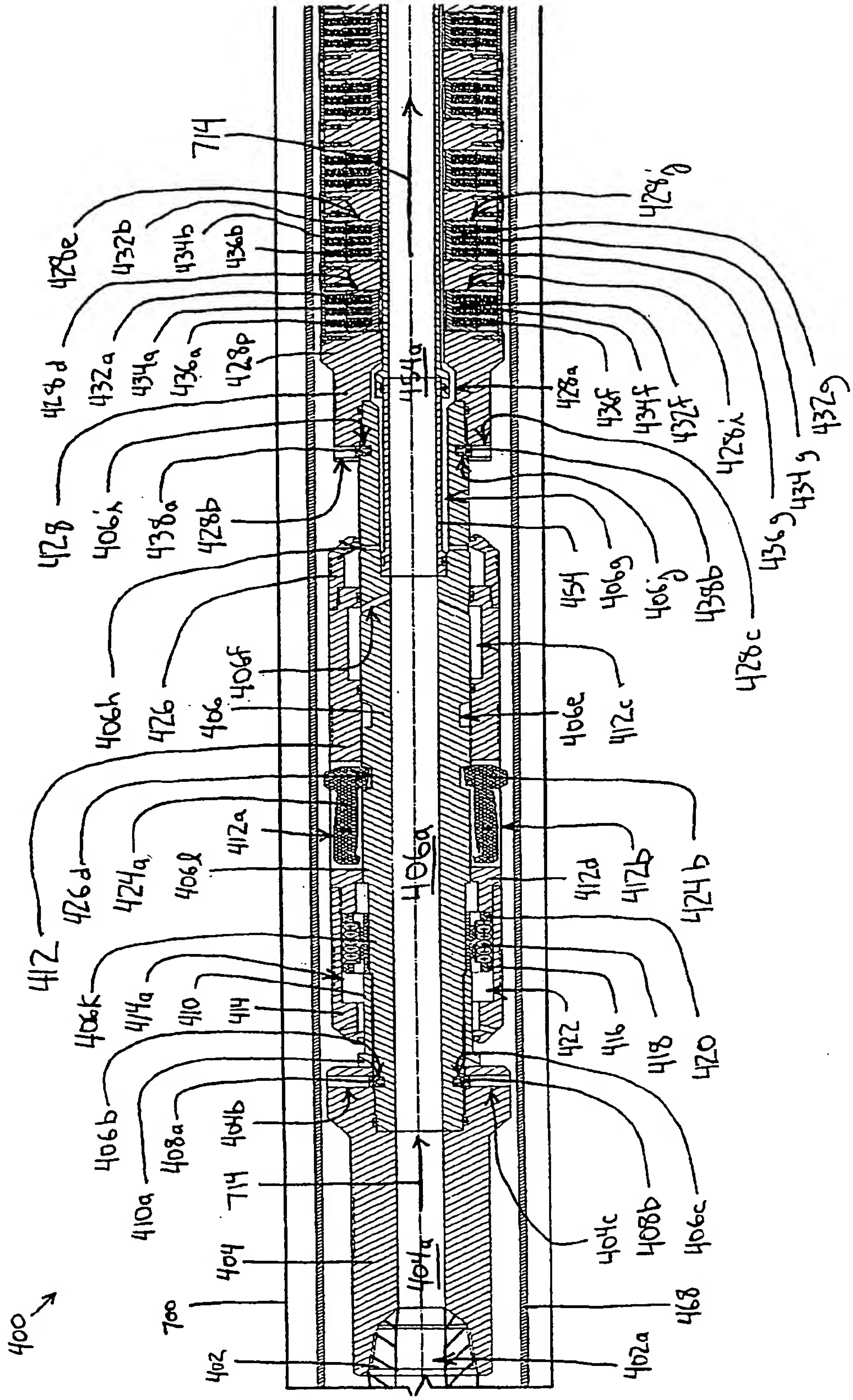

400
402
700
404
404a
714
410a
408a
406b
404b
406k
414a
410
414
412
426d
424a
406l
412a
406a
406h
426
406
406f
428
406i
438a
428b
428d
432a
434a
436a
428p
428e
432b
434b
436b
714
454a
402a
468
404c
408b
406c
422
416
418
420
412d
412b
424b
406e
412c
454
406g
406j
438b
428c
428a
436f
434f
432f
428i
434g
436g
432g
428j

Fig. 33a

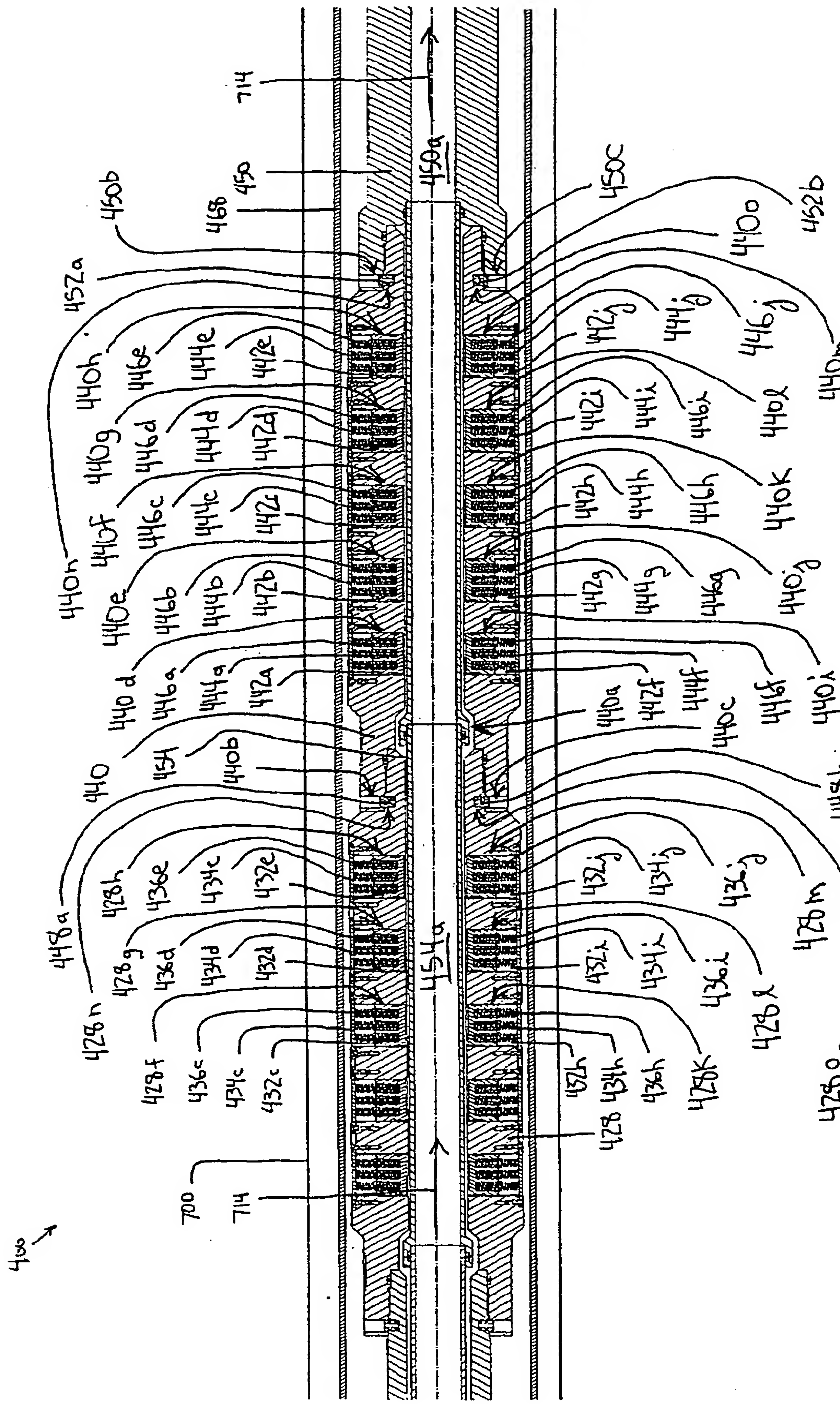

714
450
450a
468
450b
450c
452a
452b
440h
446e
444e
442e
440g
446d
444d
442d
440f
446c
444c
442c
440e
446b
444b
442b
440d
446a
444a
442a
440
454
440b
440a
440c
448a
428h
436e
434e
432e
428g
436d
434d
432d
454a
428n
428f
436c
434c
432c
700
428
428o
430

Fig. 33b

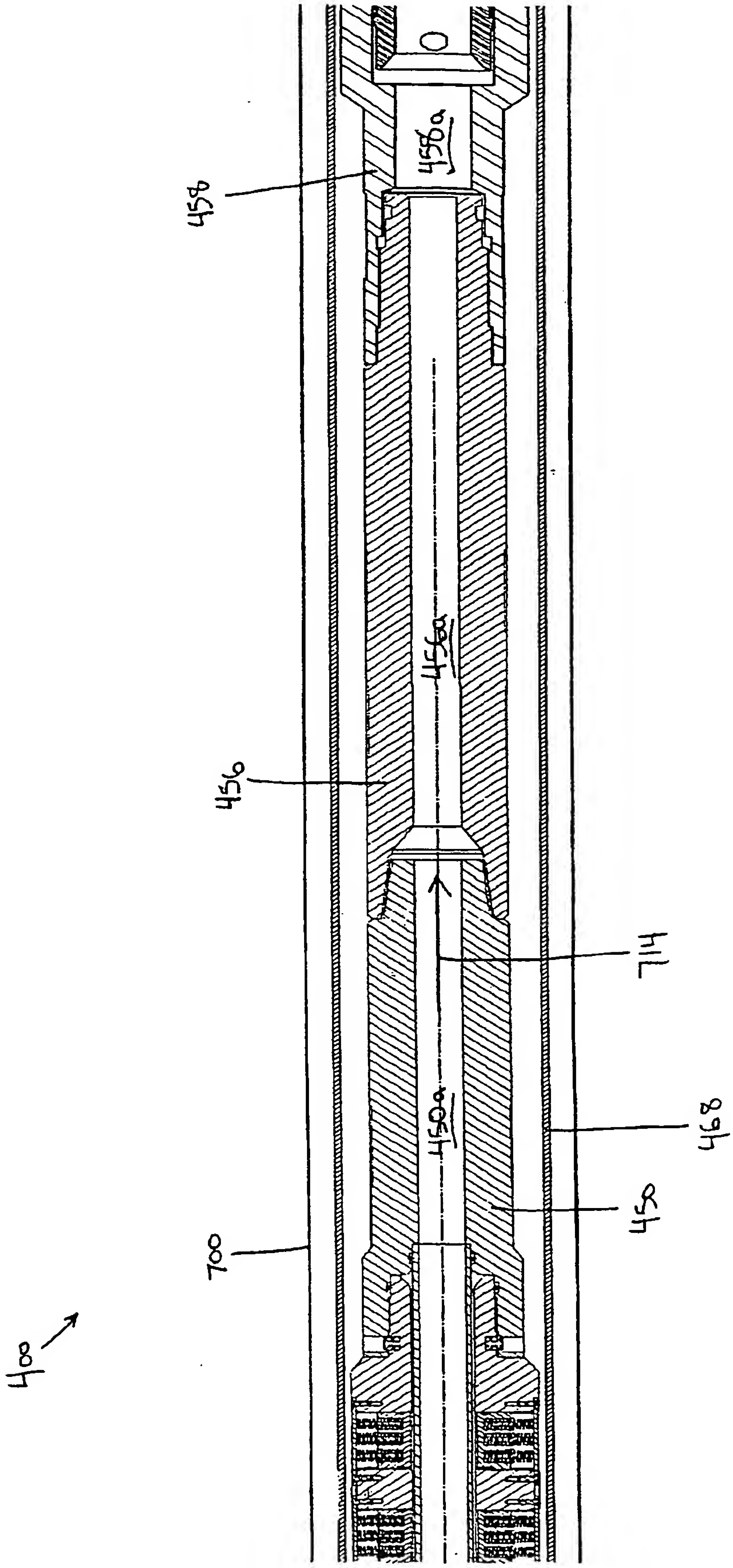


Fig. 33c

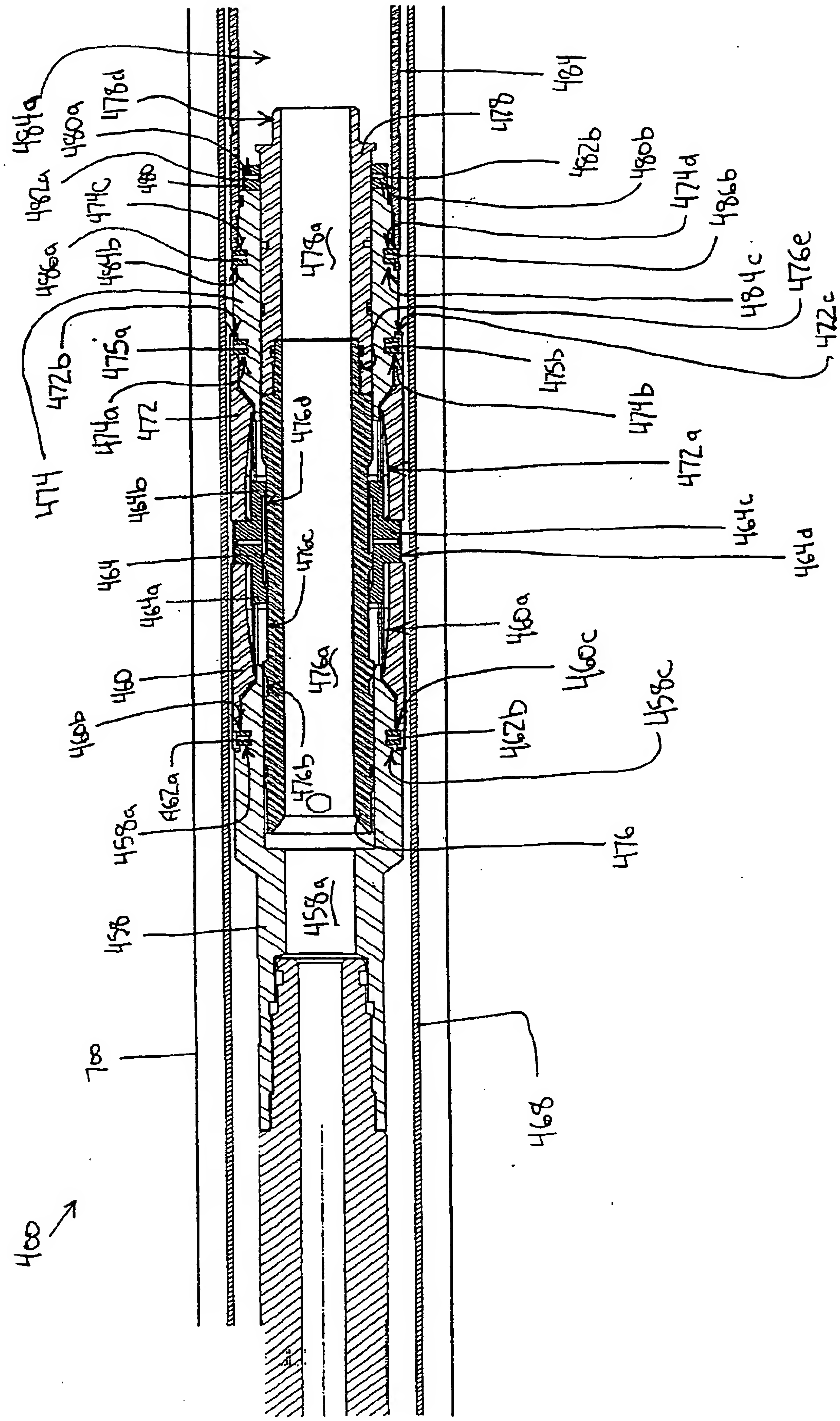

484a
478d
480a
482a
474c
480
486a
484b
472b
475a
474
474a
472
476d
464b
464
476c
464a
460
476a
460b
462a
476b
458a
458
458a
478a
700
400
464
478
482b
480b
474d
486b
484c
476e
472c
475b
474b
472a
464c
464d
460a
460c
462b
458c
476
468

Fig. 33d

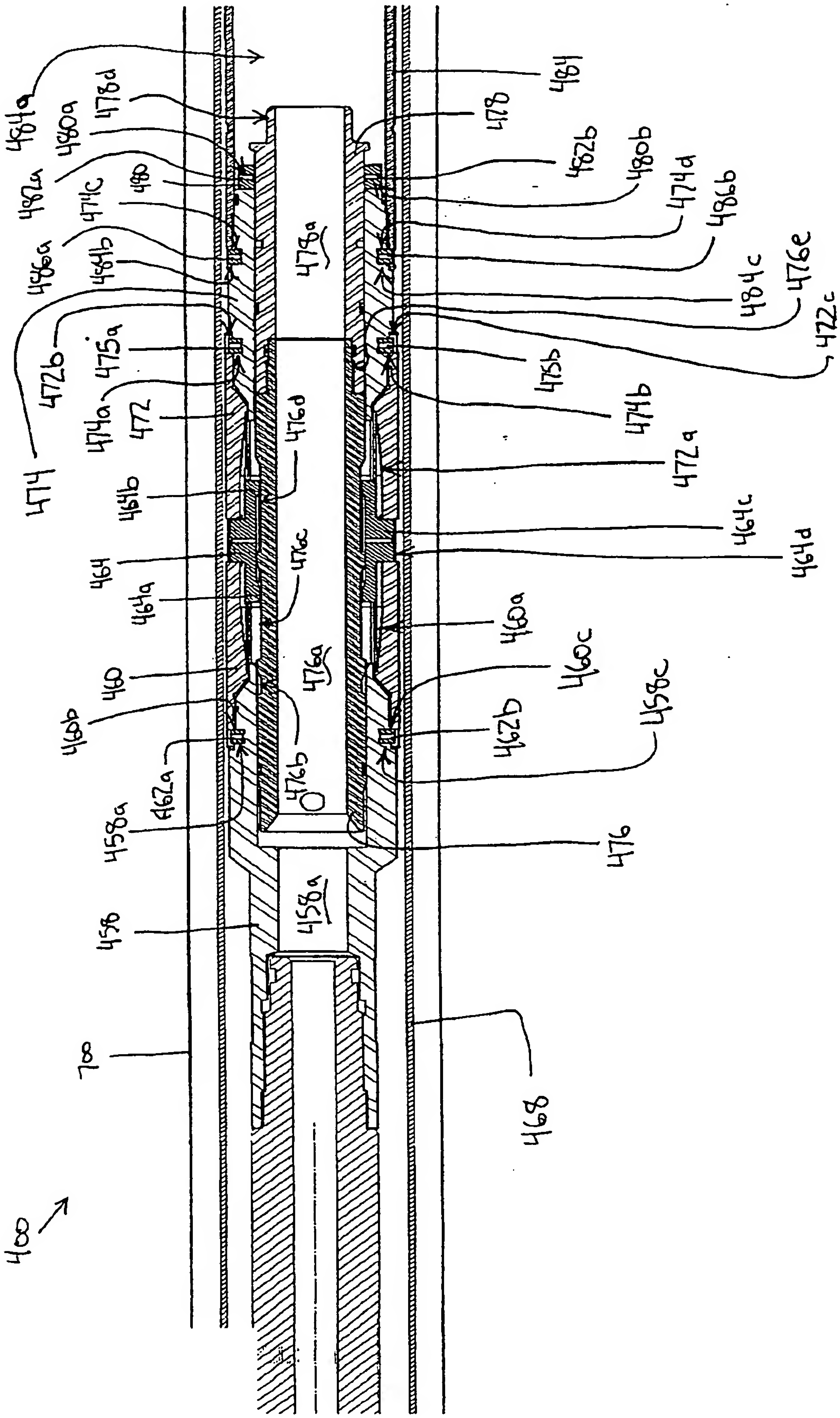

400
484a
478d
480a
482a
471c
480
486a
484b
472b
475a
474
474a
472
476d
464b
464
464a
476c
460
476a
460b
462a
476b
458a
458
458a
78
484
478
479a
462b
480b
474d
486b
484c
476e
472c
475b
474b
472a
464c
464d
460a
460c
462b
458c
476
468

Fig. 33d

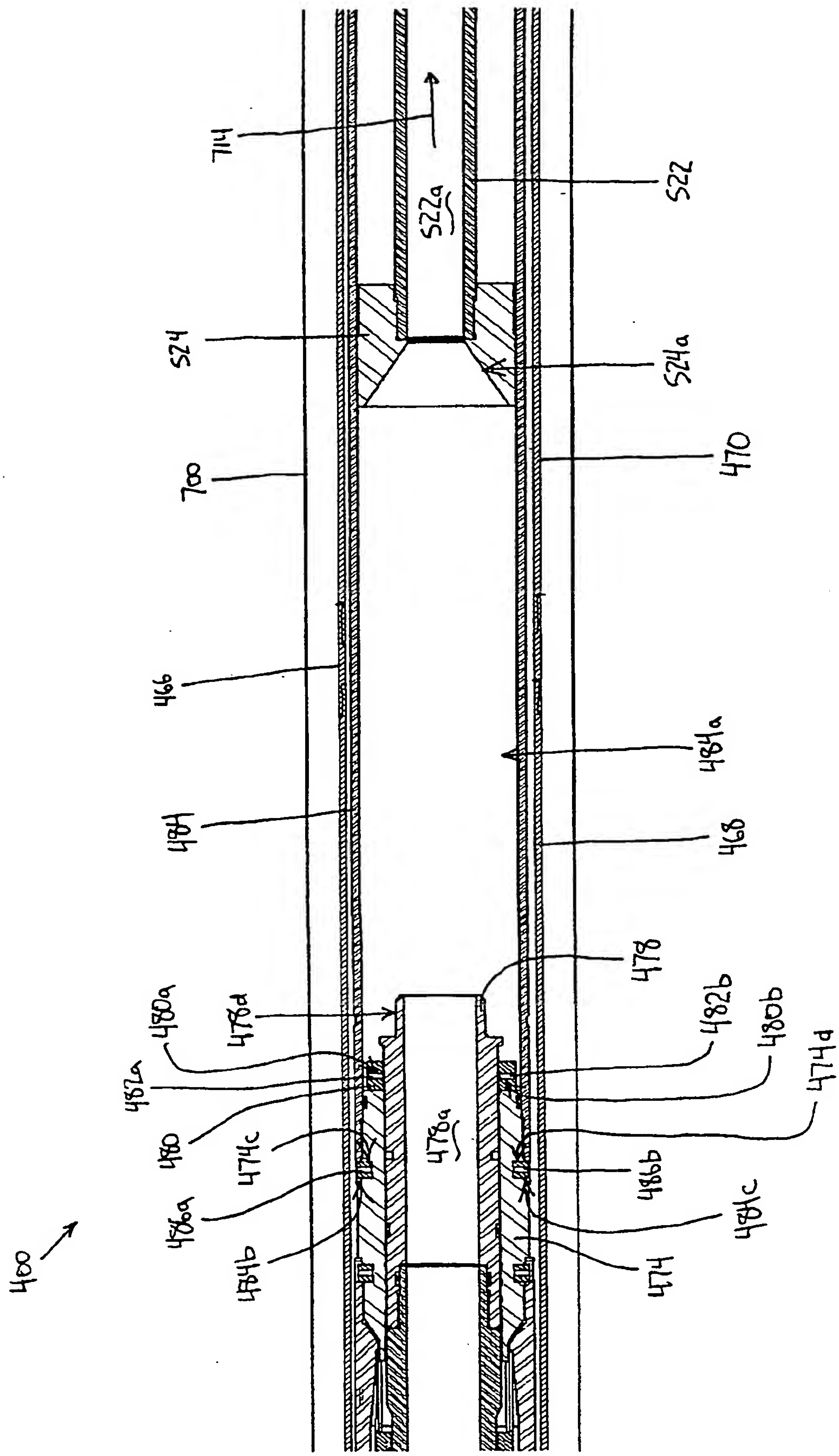

714
522
522a
524
524a
700
470
466
484a
484
468
478
476a
480a
476d
482b
480b
482a
474d
480
474c
476a
486b
486a
484c
484b
474
400

Fig. 33e

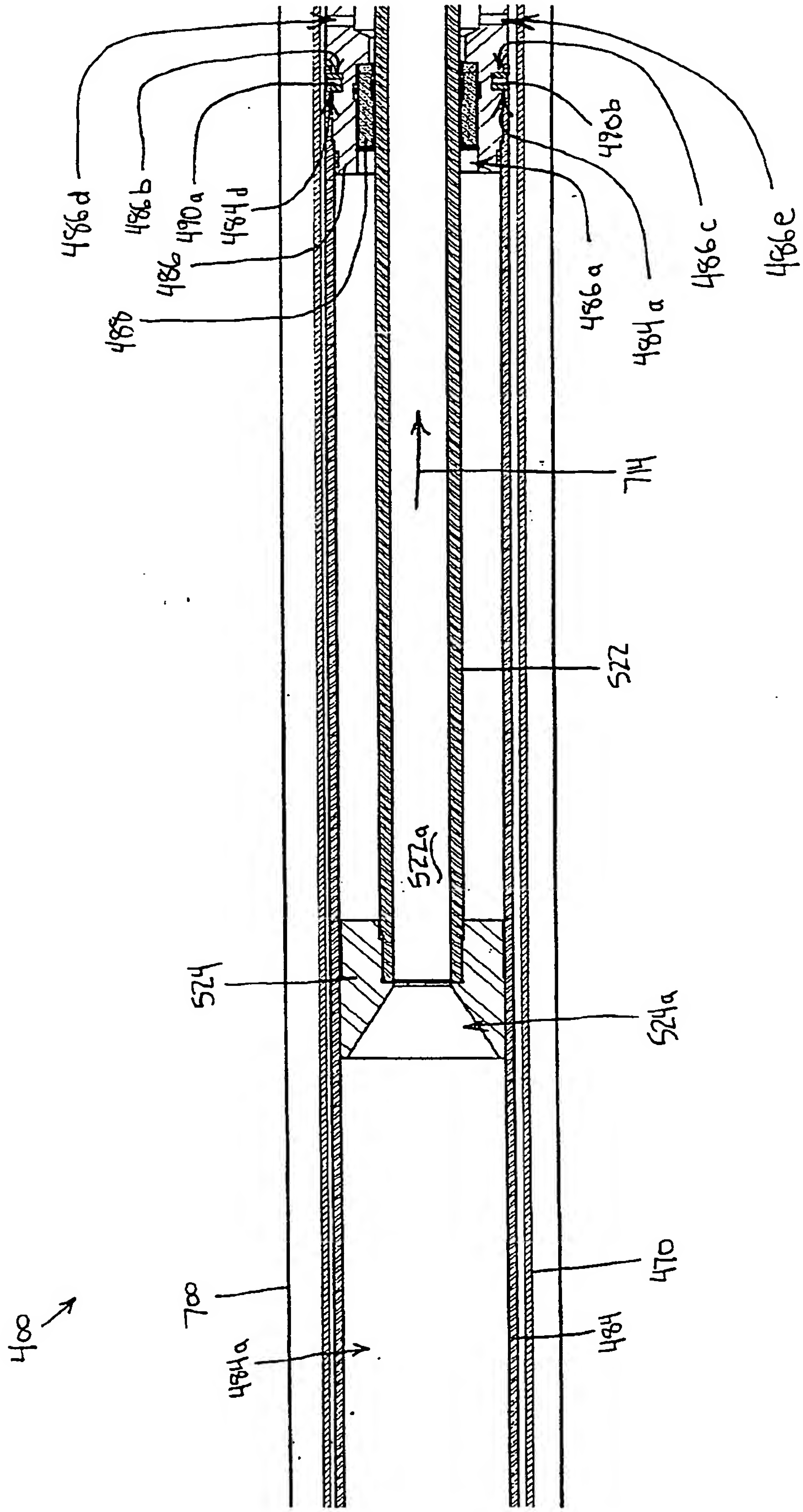
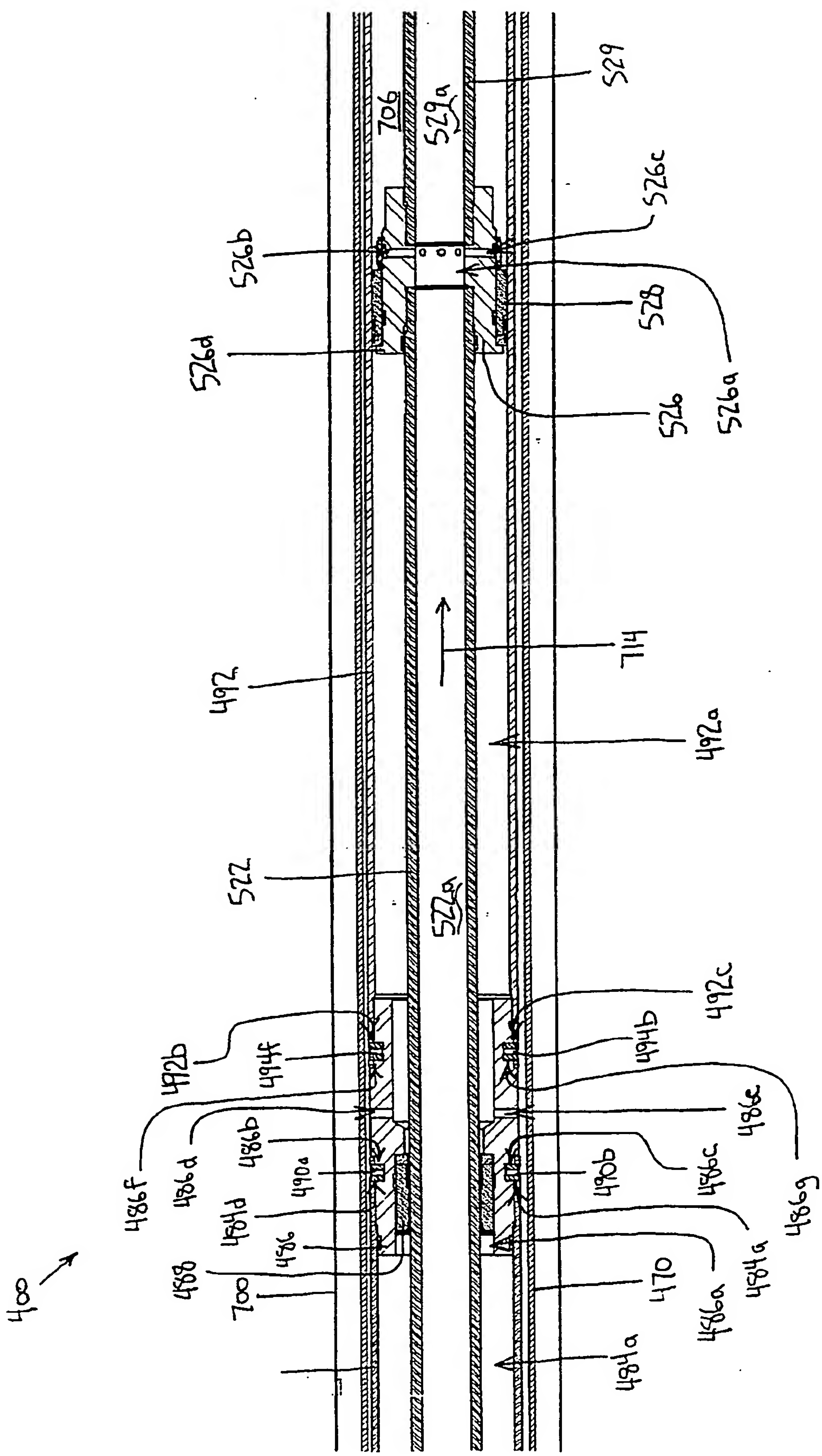

486d
486b
490a
484d
486
488
486a
484a
486c
486e
490b
714
522
522a
524
524a
400
700
484a
470
484

Fig. 33f



529
529a
706
526c
526b
528
526d
526
526a
714
492
492a
522
522a
492c
492b
494f
494b
486f
486d
486b
486e
490a
490b
486c
484d
486g
486
484a
488
700
470
486a
400

Fig. 33g

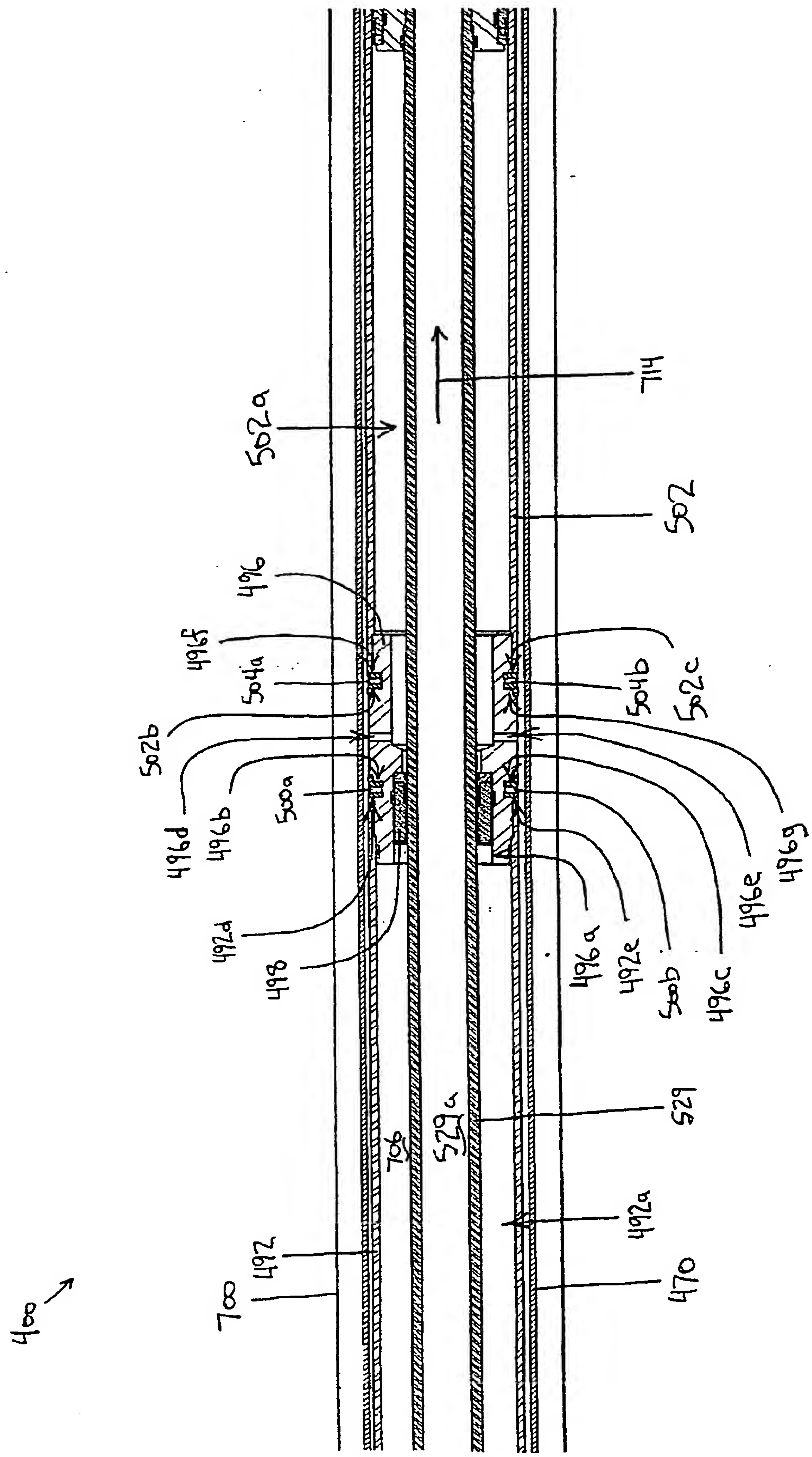
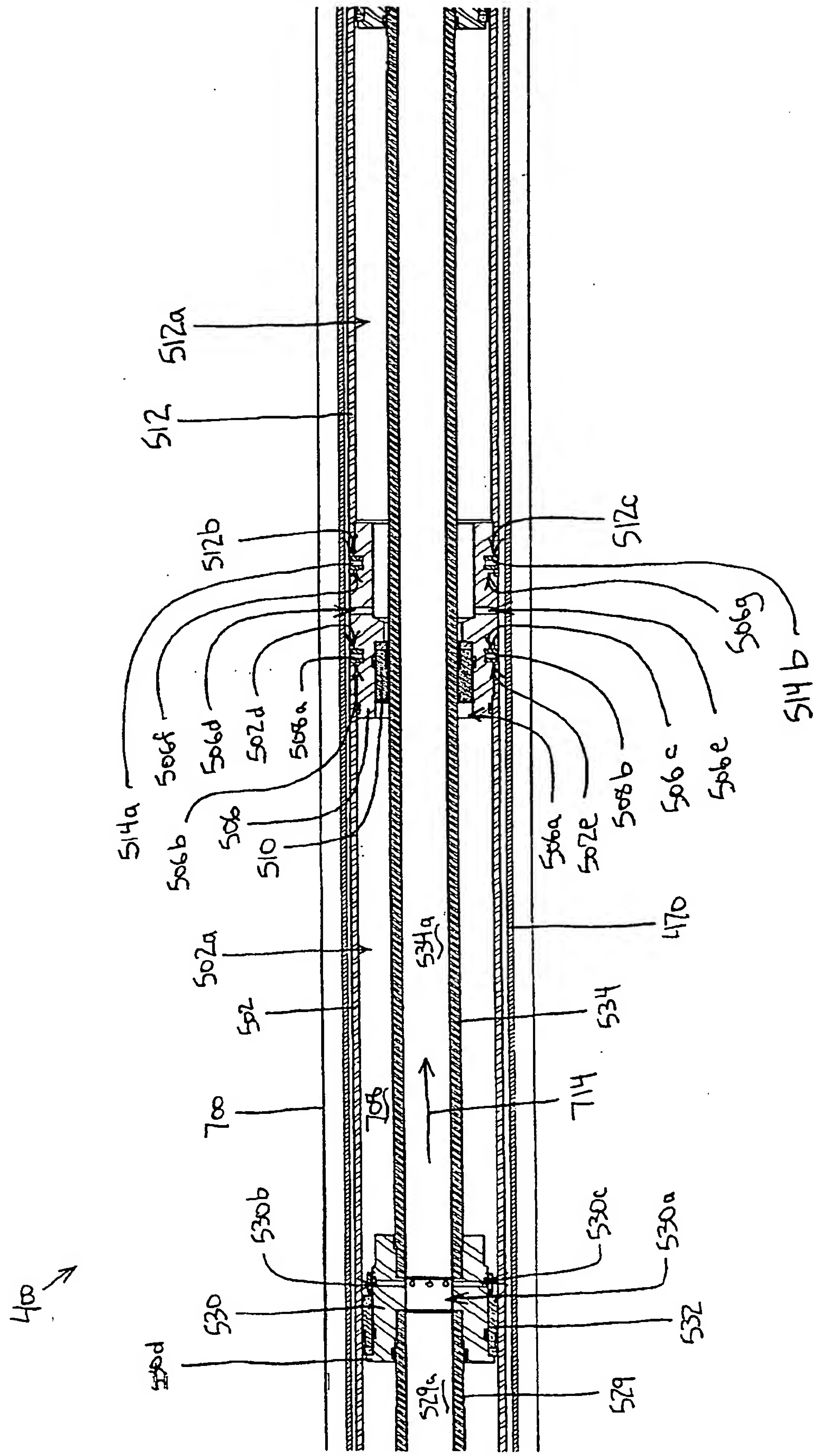

400
700
492
706
529a
529
492a
470
498
492d
496d
496b
500a
502b
504a
496f
496
502a
714
502
502c
504b
496g
496e
496c
500b
492e
496a

Fig. 33h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512a
512
512b
512c
514a
506f
506d
502d
508a
506g
514b
506b
506
510
508a
502e
508b
506c
506e
502a
534a
470
502
534
700
708
714
530b
530c
530a
530
532
530d
529a
529

Fig. 33I

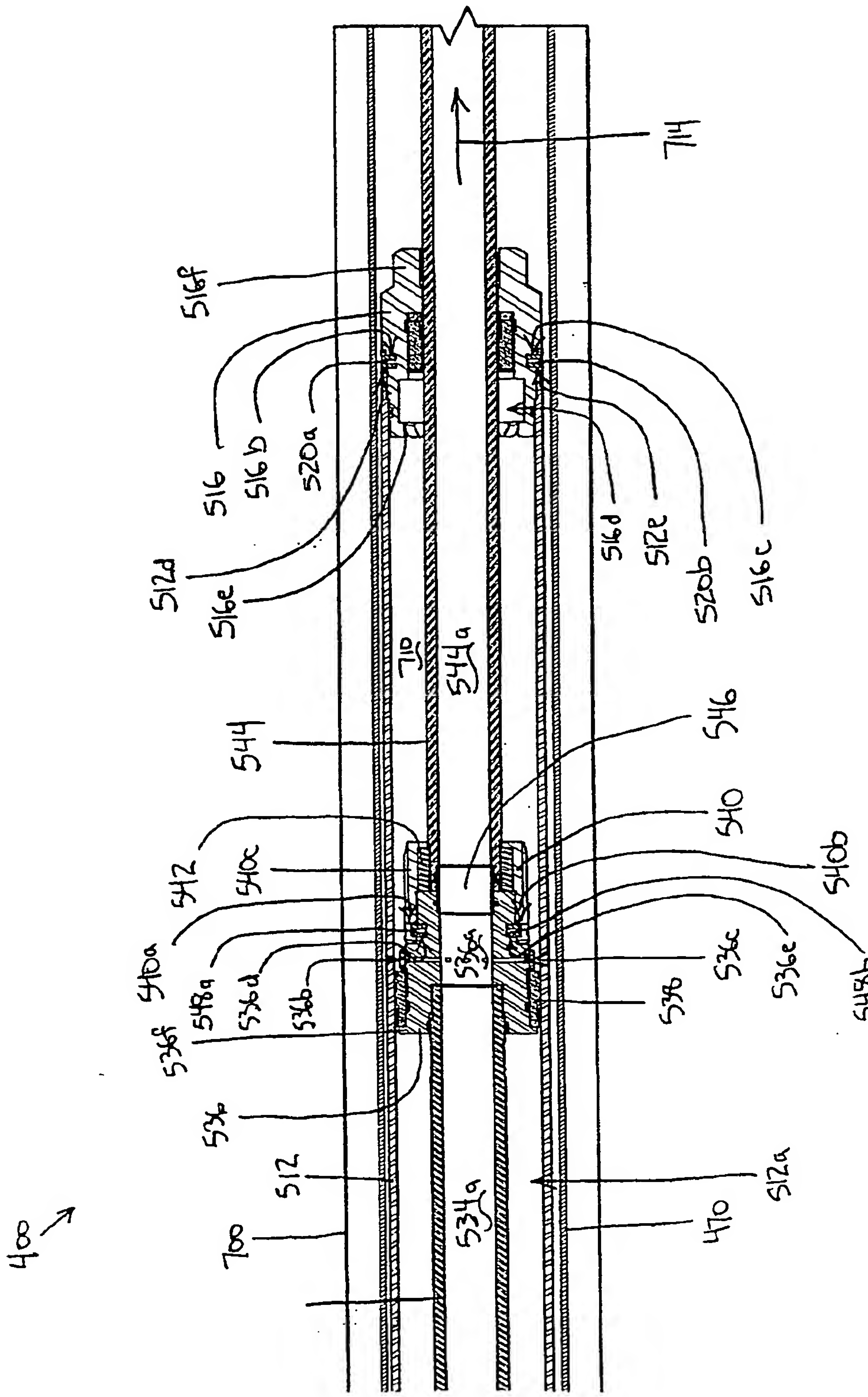
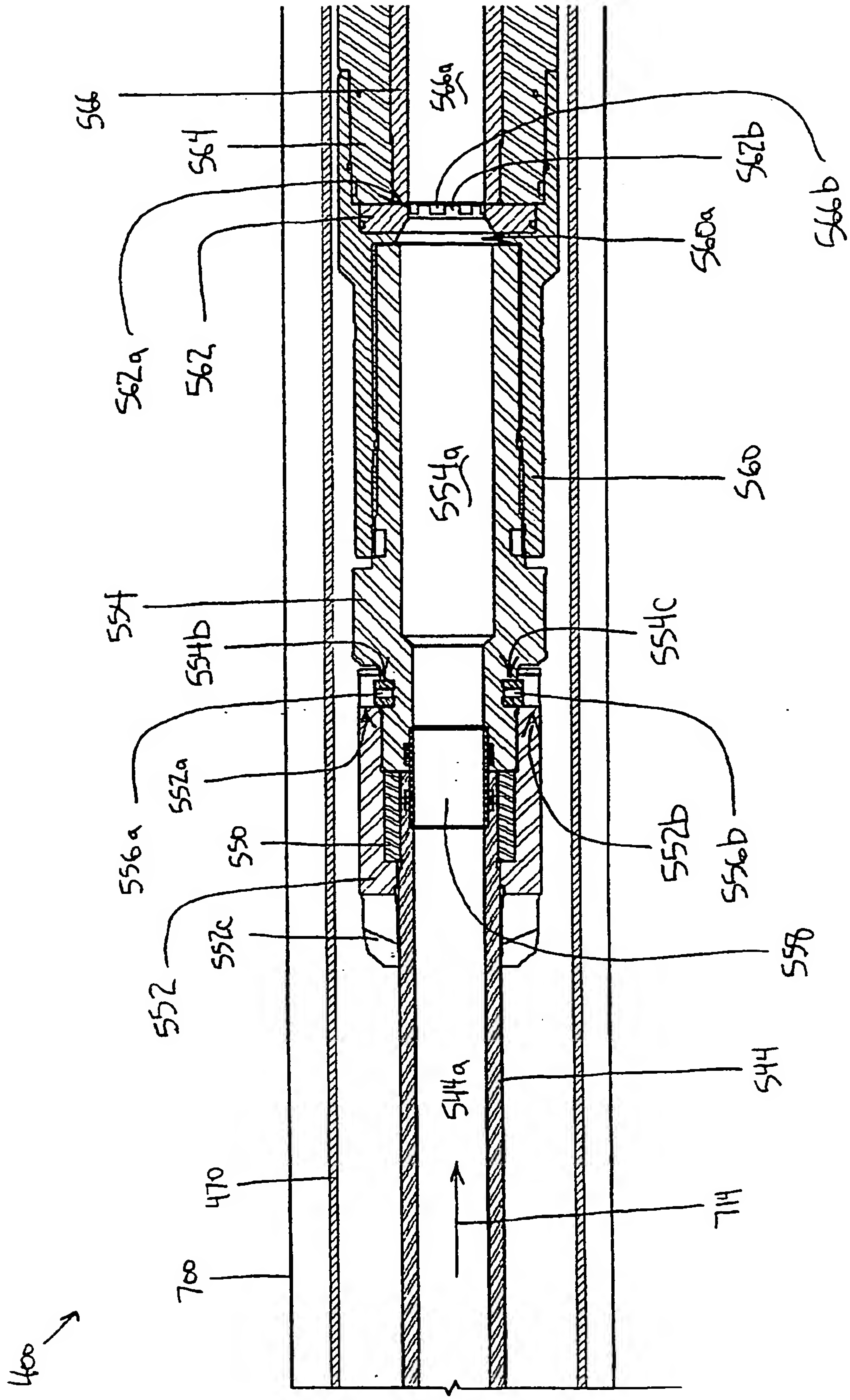

400
700
512
534a
536
536f
536b
536d
548a
540a
542
540c
544
710
544a
512d
516e
516
516b
520a
516f
714
516d
512e
520b
516c
546
540
540b
548b
536e
536c
536
536a
512a
470

Fig. 33J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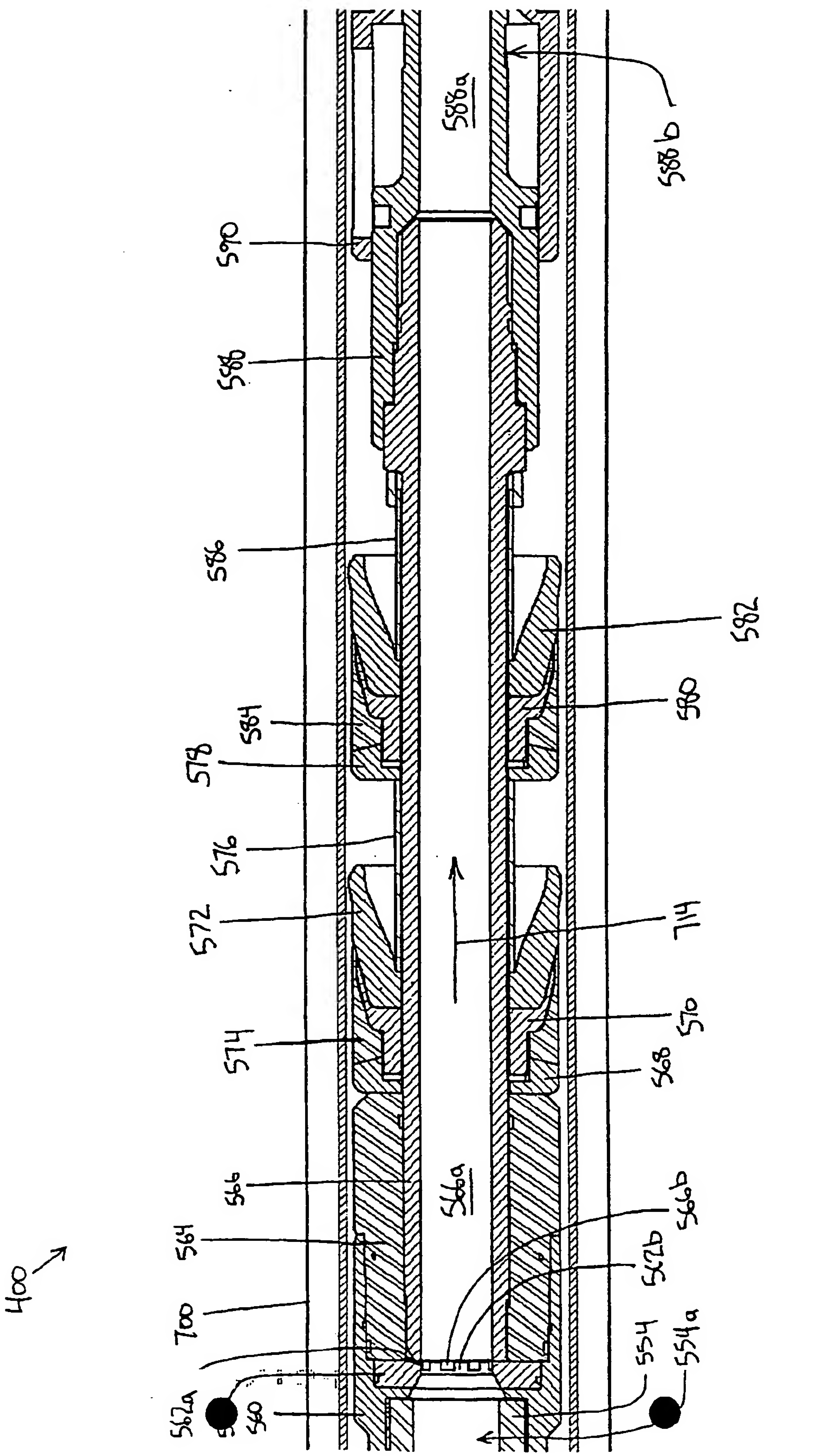
566a
564
562b
566b
560a
562a
562
554a
560
554
554b
554c
556a
552a
550
552b
556b
552c
558
552
544
544a
470
714
700
400

Fig. 33k



586a
586b
590
588
586
582
580
584
578
576
572
714
574
570
568
566
566a
564
566b
562b
700
554
554a
562a
560
400

Fig. 33I

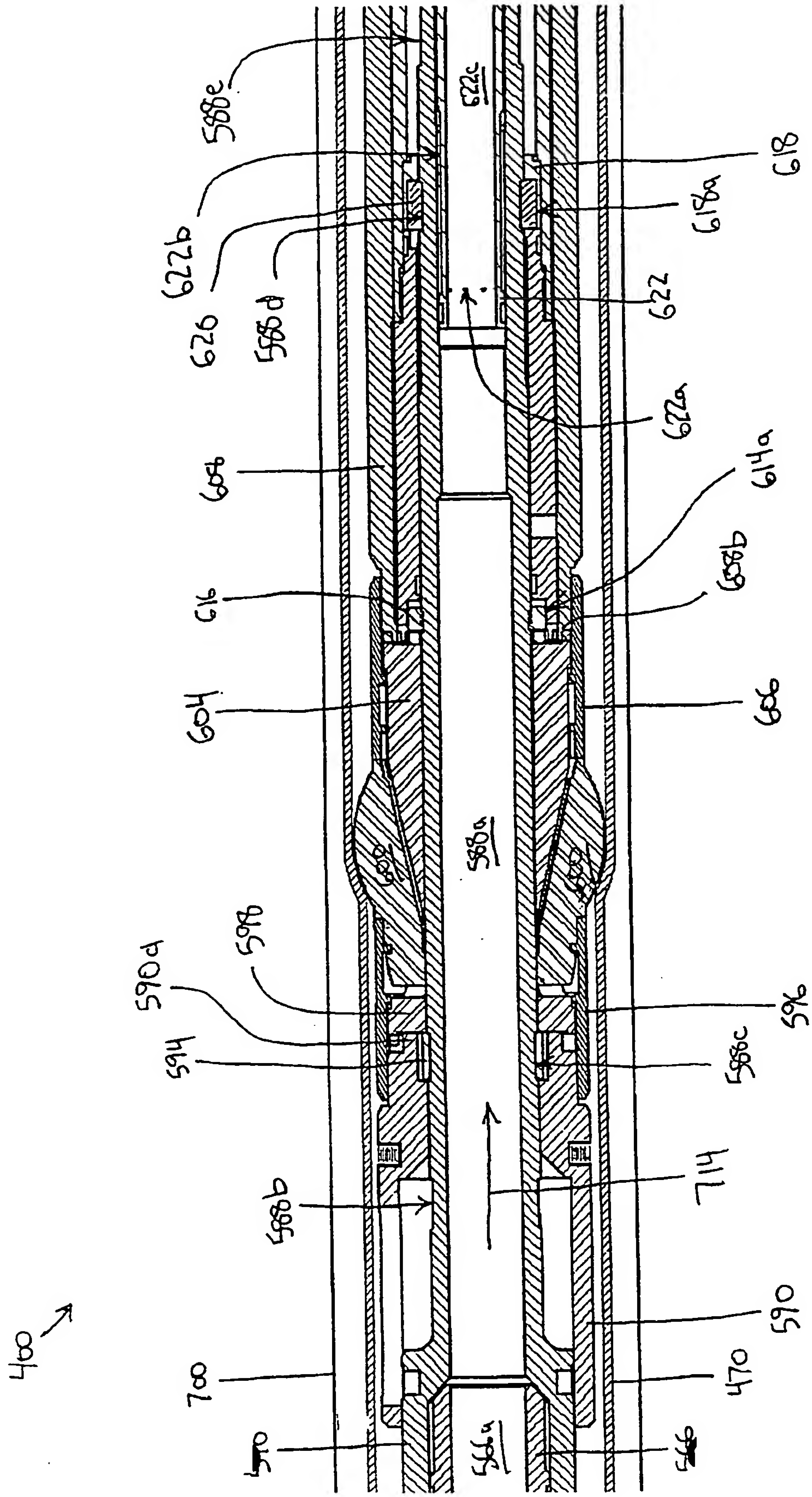

588e
622c
618
618a
622b
626
588d
622
622a
608
614a
608b
616
604
606
588a
602
598
590a
594
596
588c
714
588b
400
700
470
590
566a
566

Fig. 33m

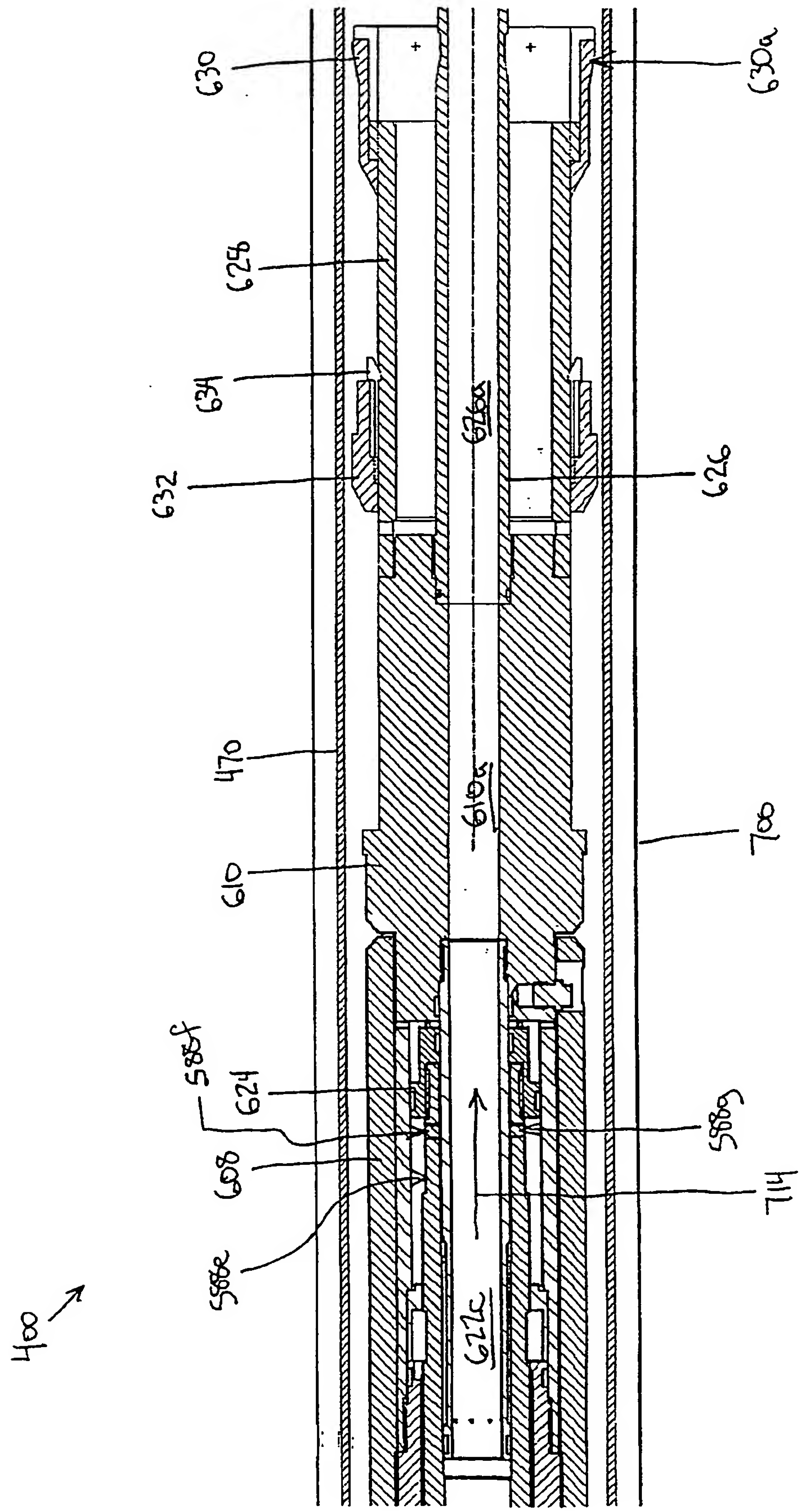

630
630a
628
634
626a
632
626
470
610a
700
610
588f
624
588g
608
714
588e
622c
400

Fig. 33n

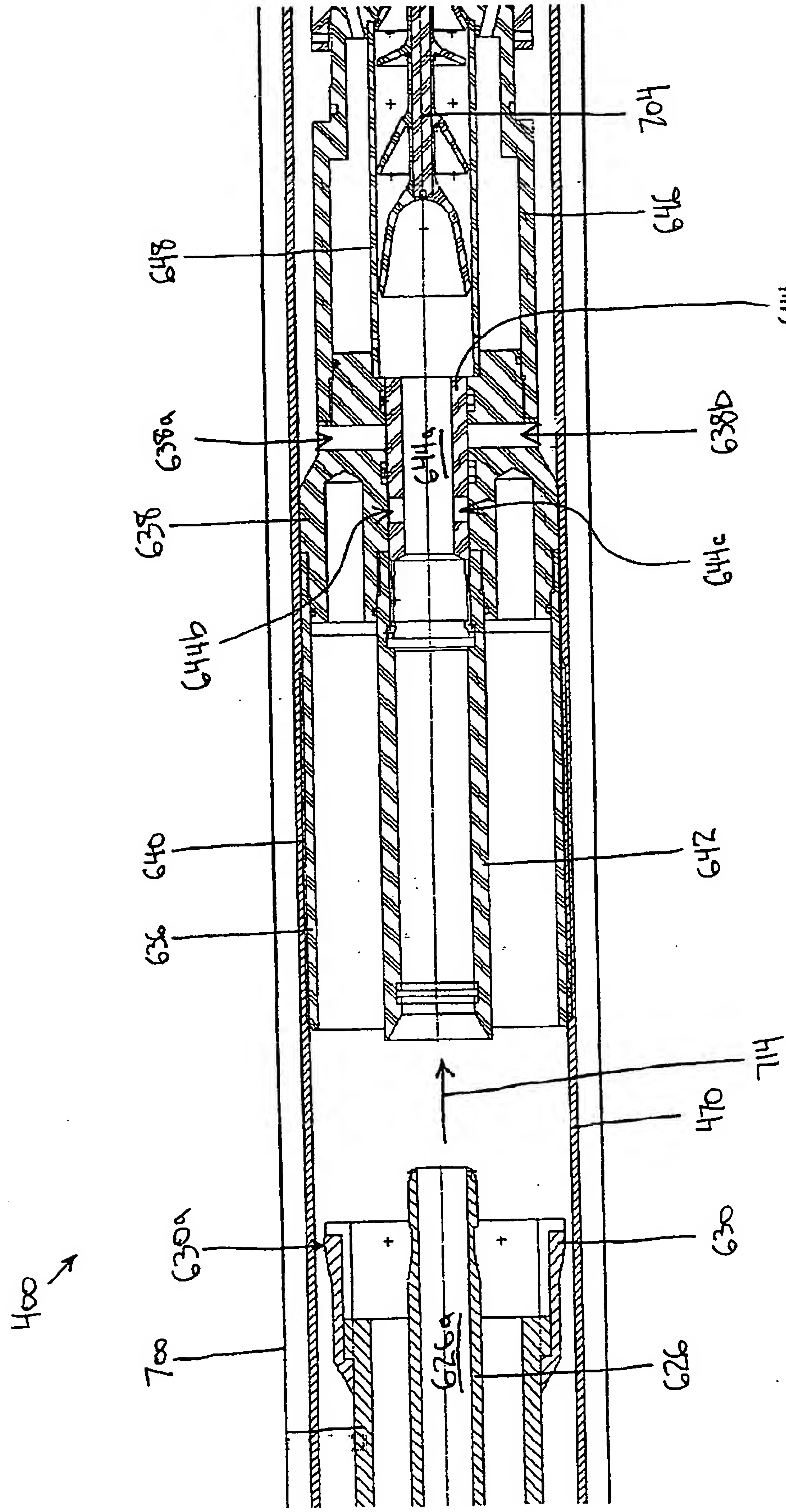

704
646
648
644
638a
638b
644a
638
644c
644b
640
642
636
714
470
630a
630
400
700
626a
626

Fig. 33o

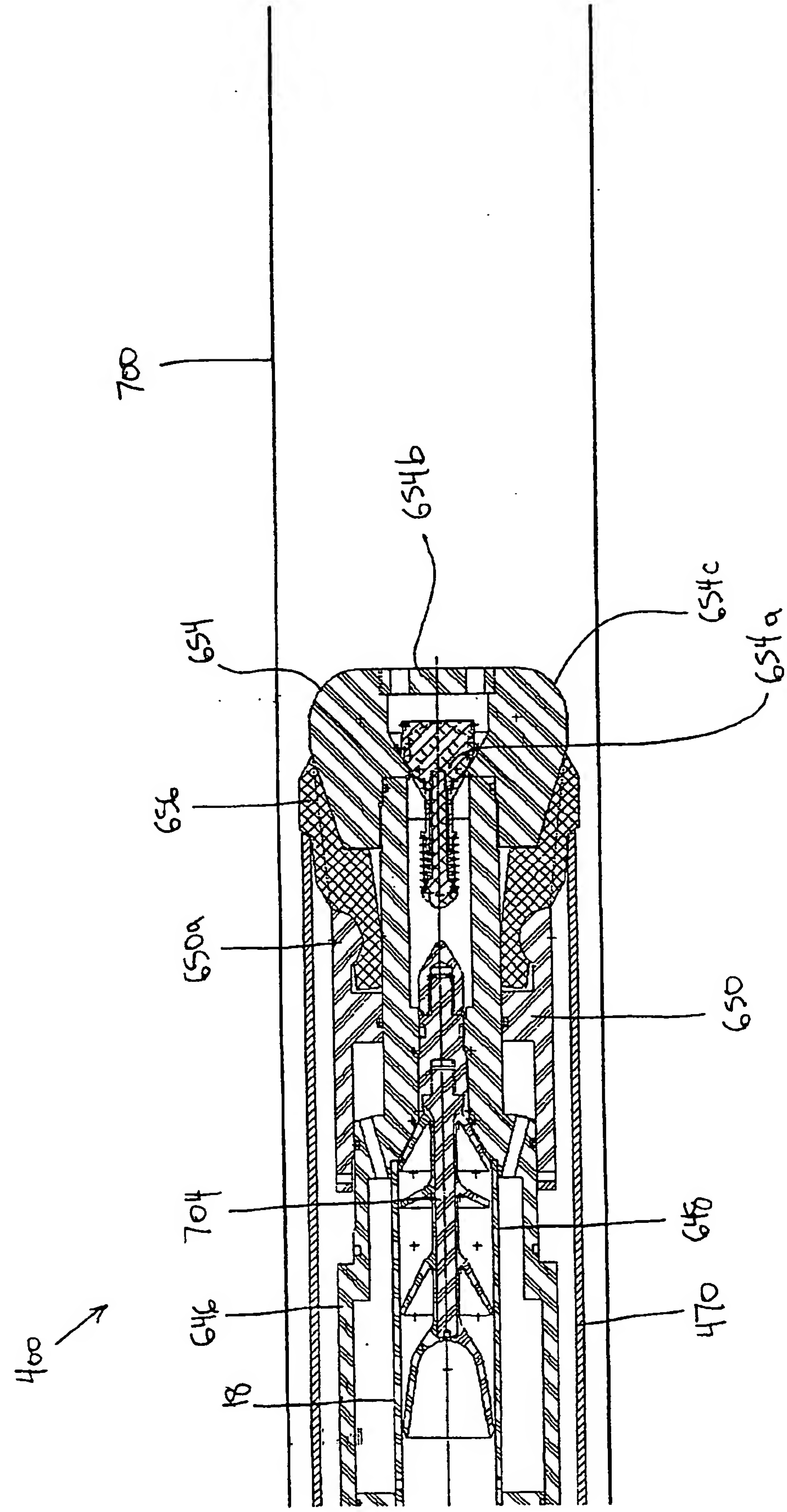


Fig. 33p

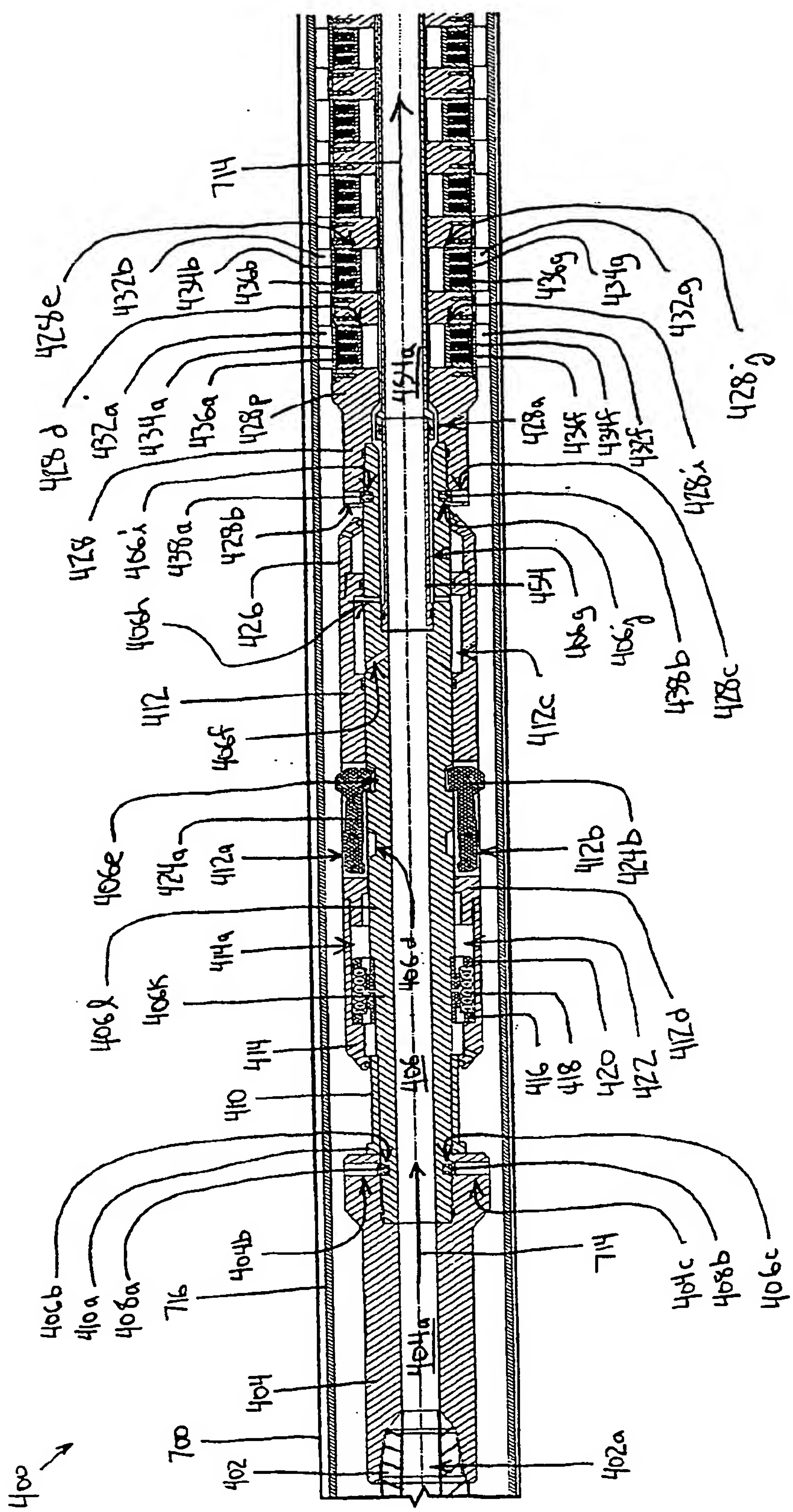


Fig. 34a

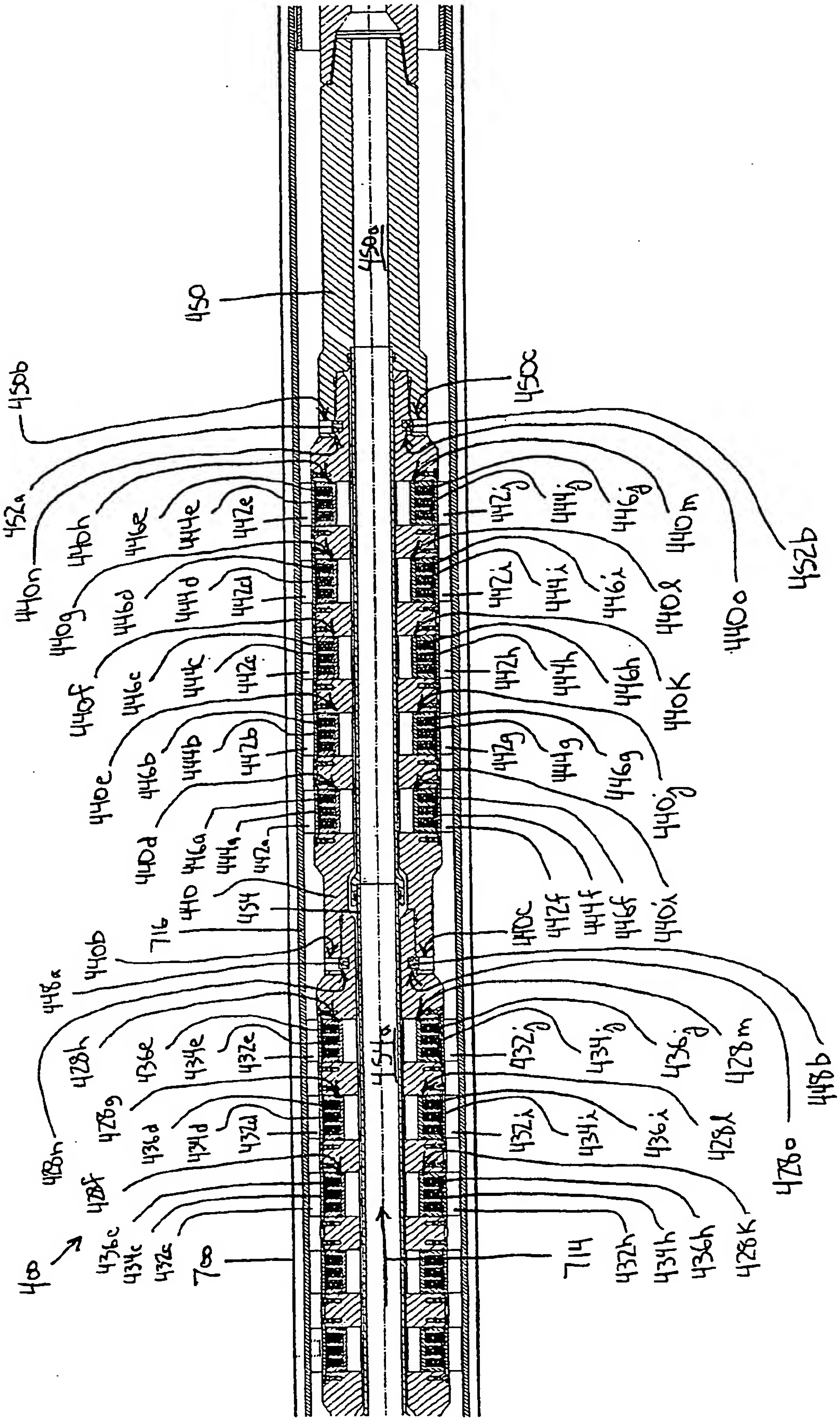


Fig. 34b

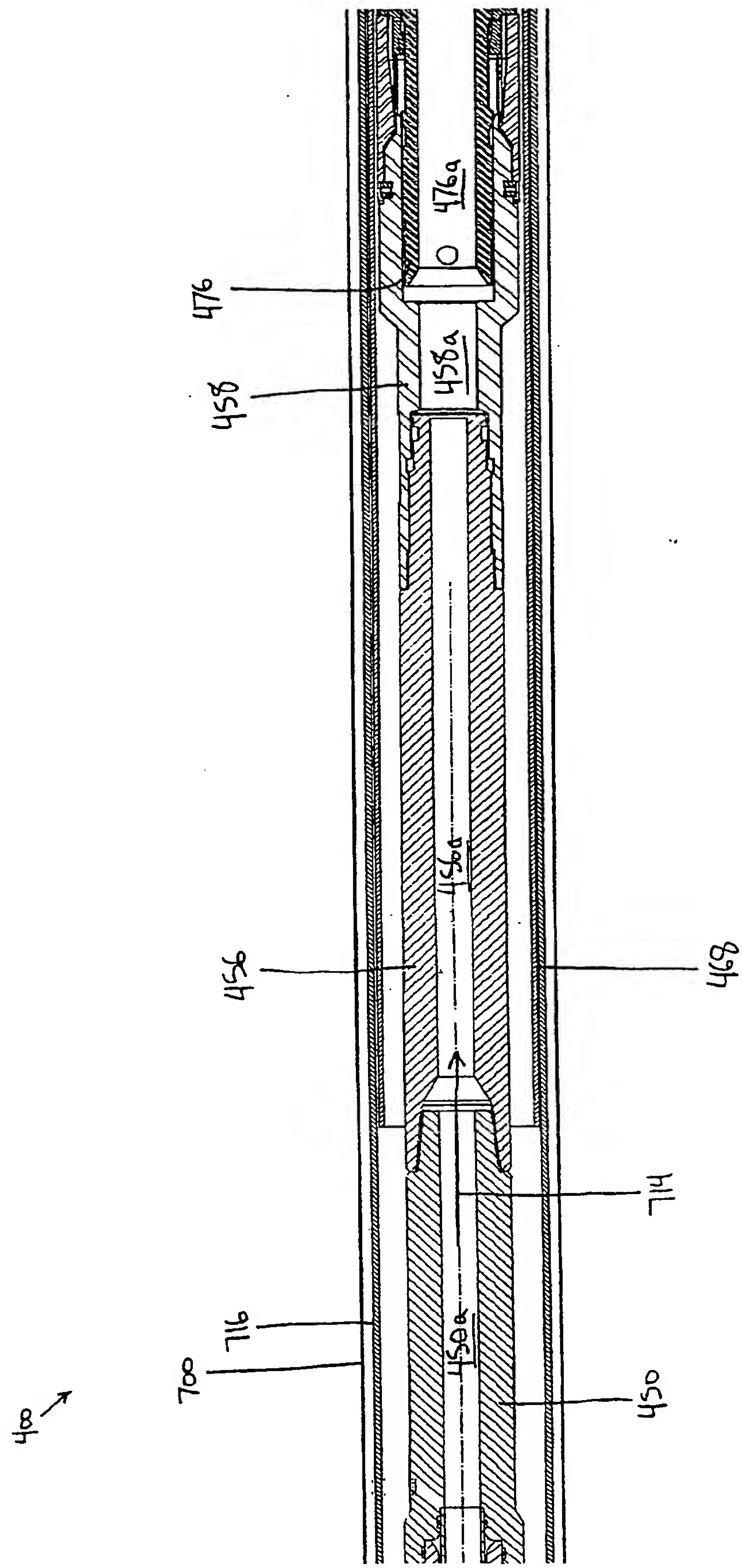
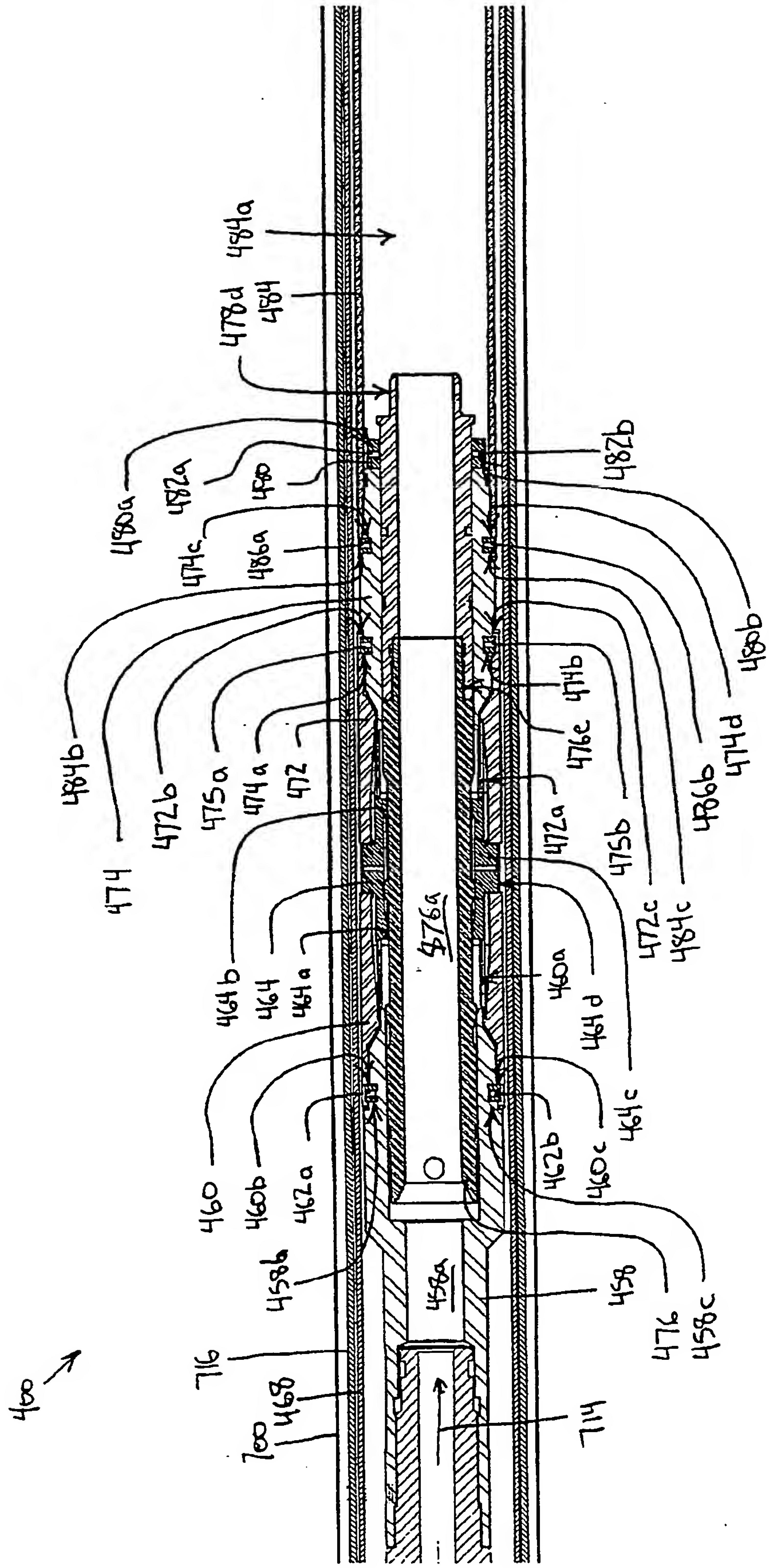


Fig. 34c


484a
478d
484
482b
480a
482a
480
474c
486a
480b
484b
474
472b
475a
474a
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474b
476e
474d
486b
472a
475b
472c
484c
476a
464b
464
464a
460a
464d
460
460b
462a
462b
460c
464c
458b
458a
458
476
458c
716
468
700
714
400

Fig. 34d

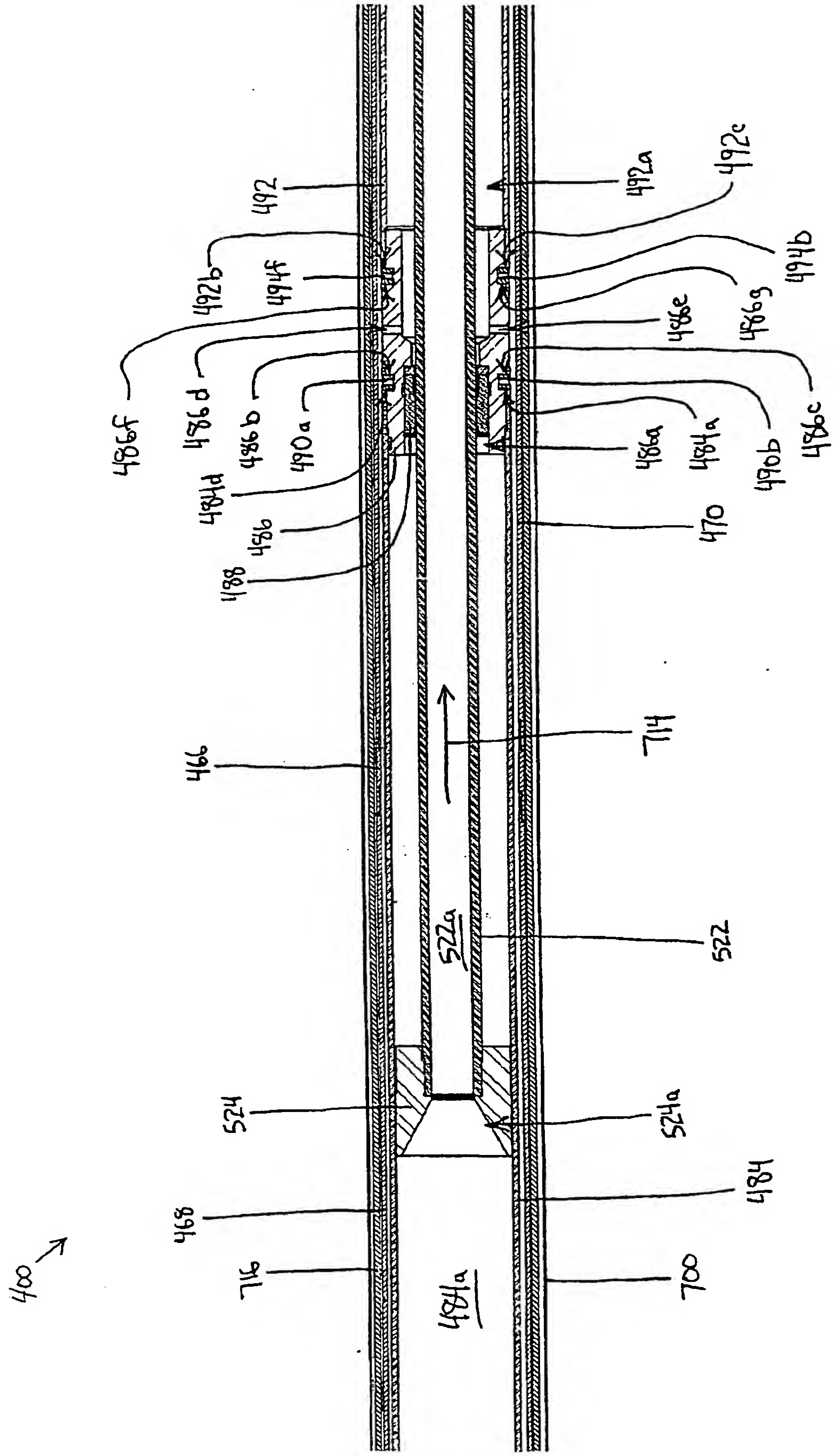
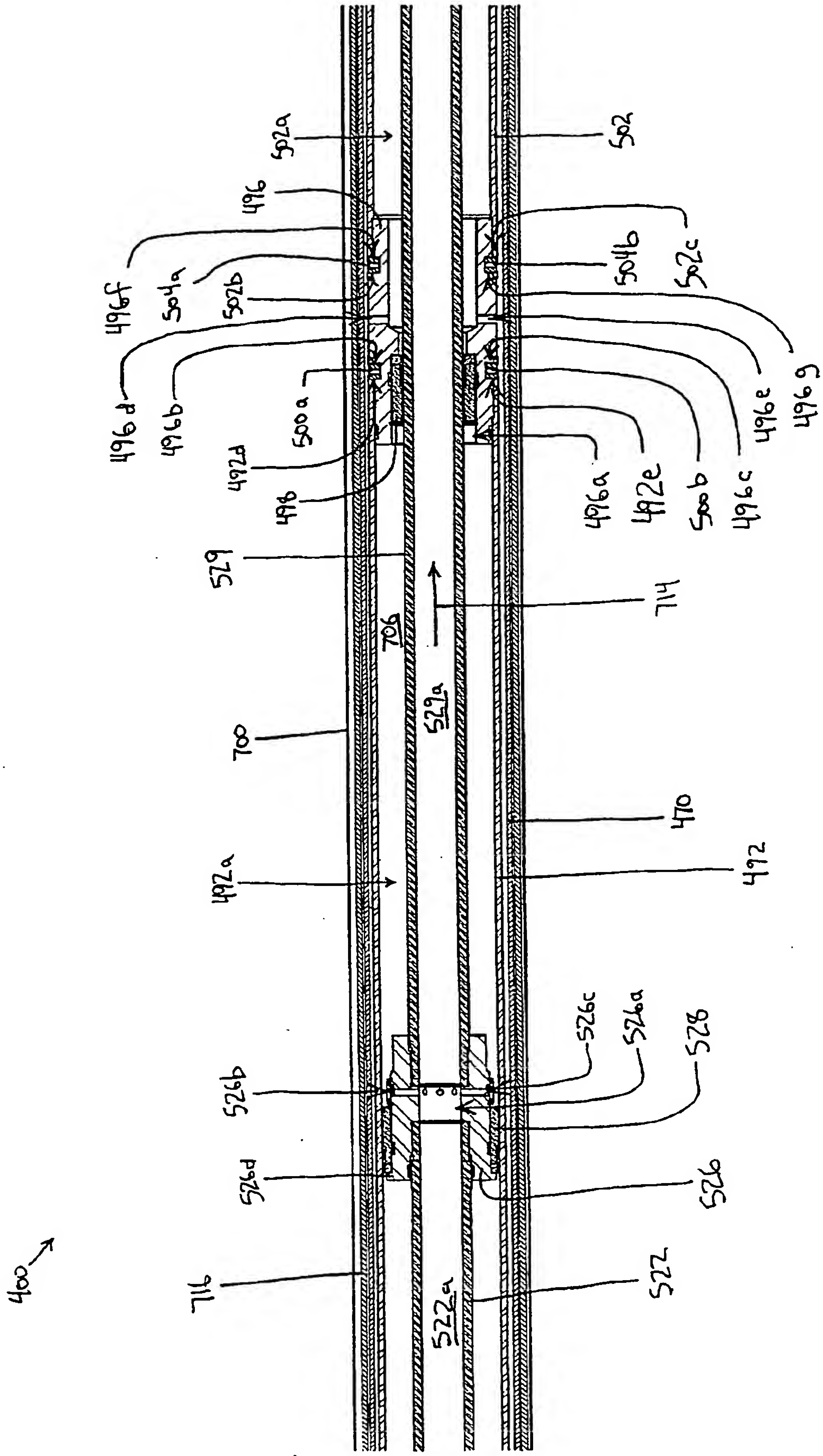

400
492
492a
492c
492b
494f
494b
486f
486e
486g
486d
486b
490a
486c
486a
484a
484d
490b
486
470
488
466
714
522a
522
524
524a
468
484
716
484a
700

Fig. 34e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496a
529
714
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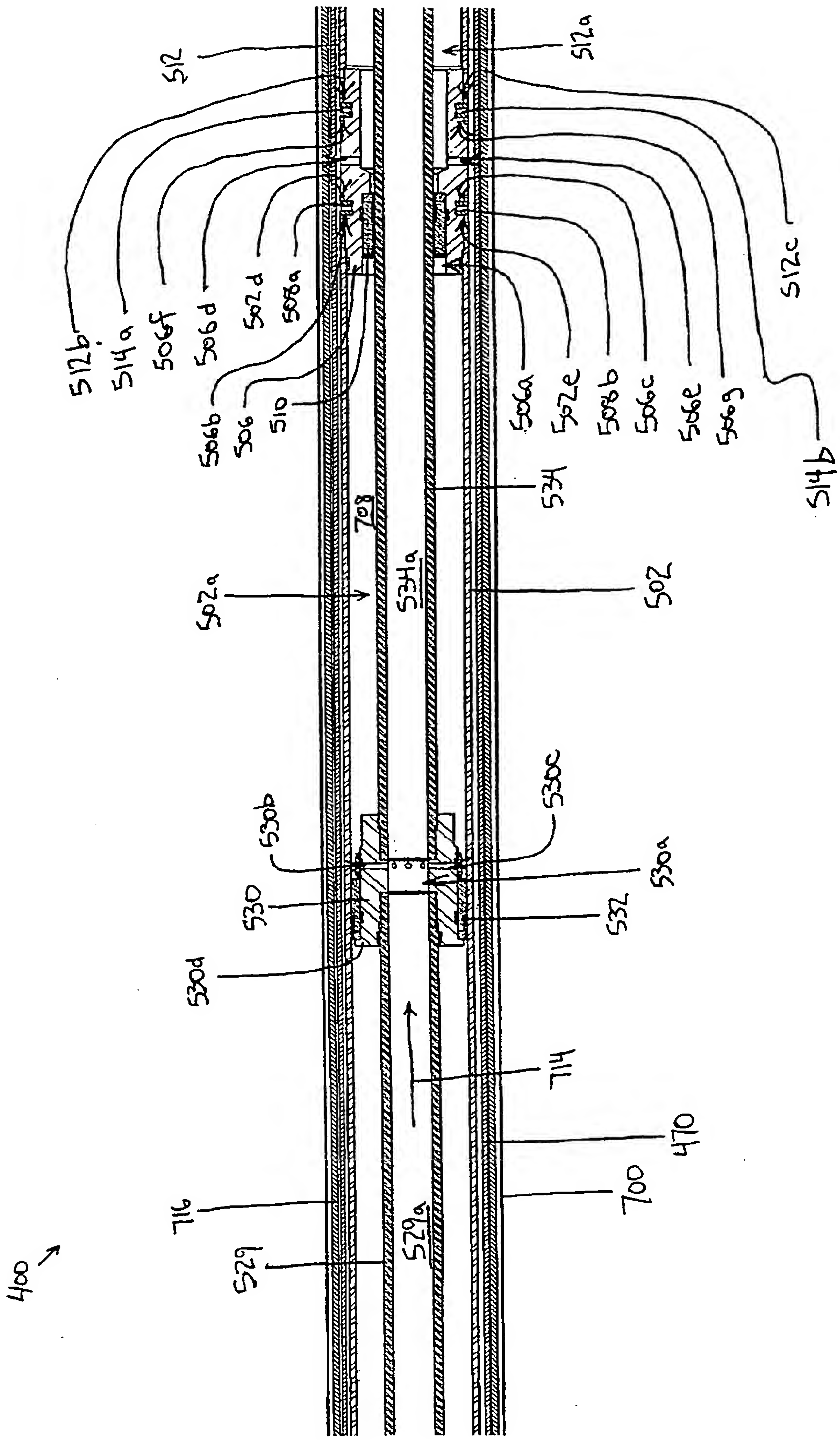
526b
526d
526
716
522a
522
400

Fig. 34f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514b
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708
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530a
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530d
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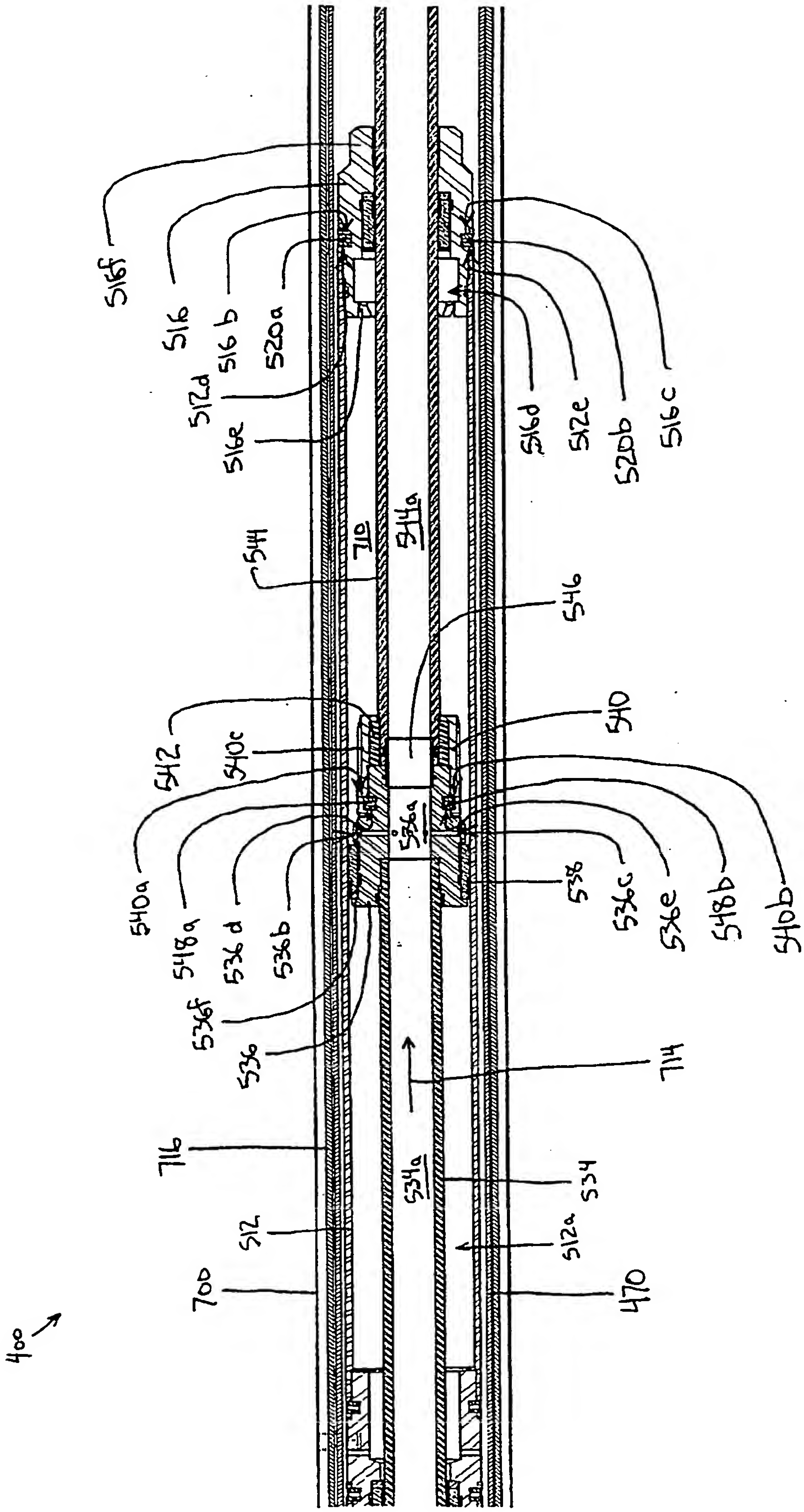
470
700
716
529
529a
400

Fig. 34g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536d
536b
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548b
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536f
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716
512
534a
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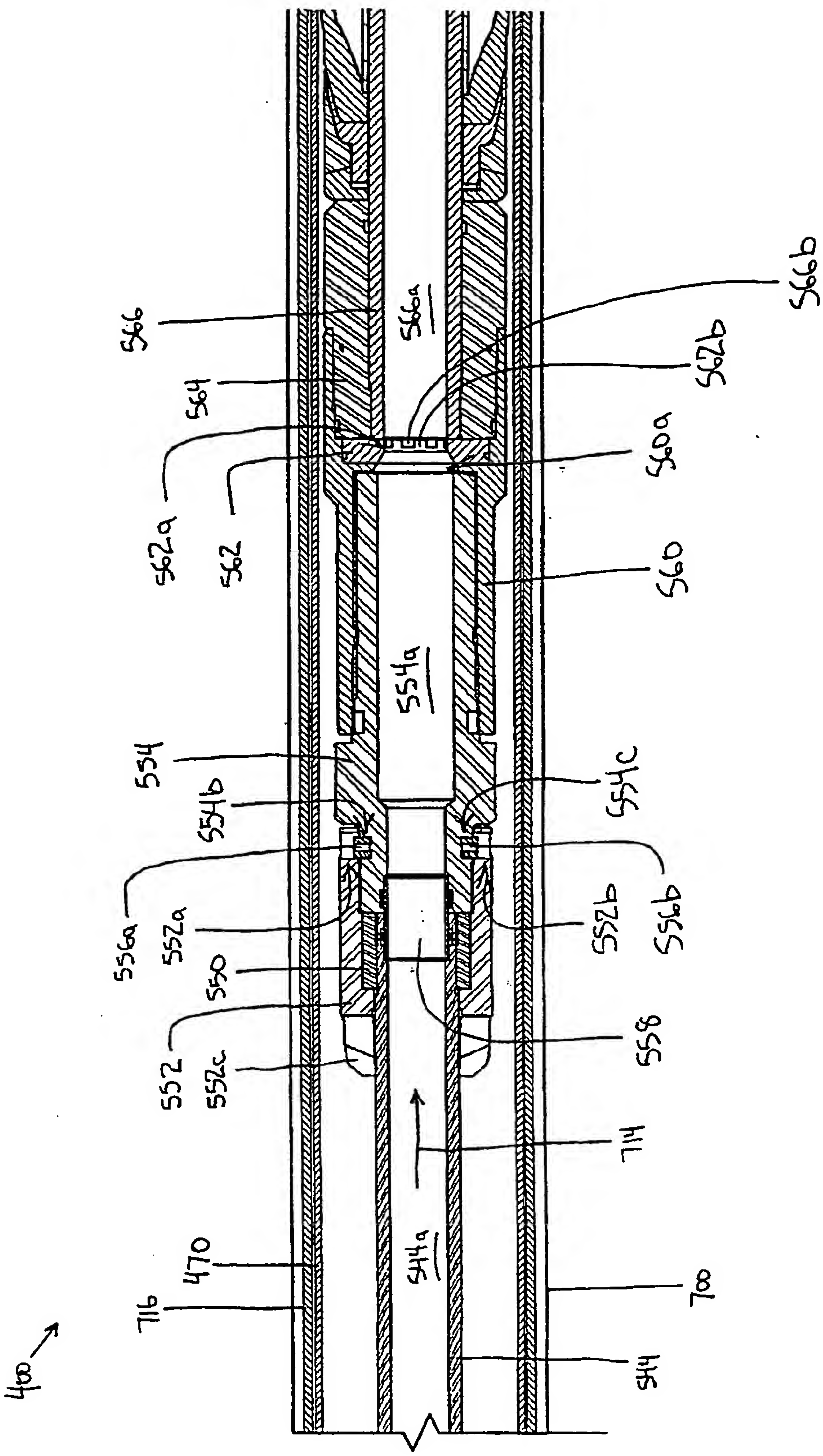
512a
700
470

Fig. 34h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552c
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716
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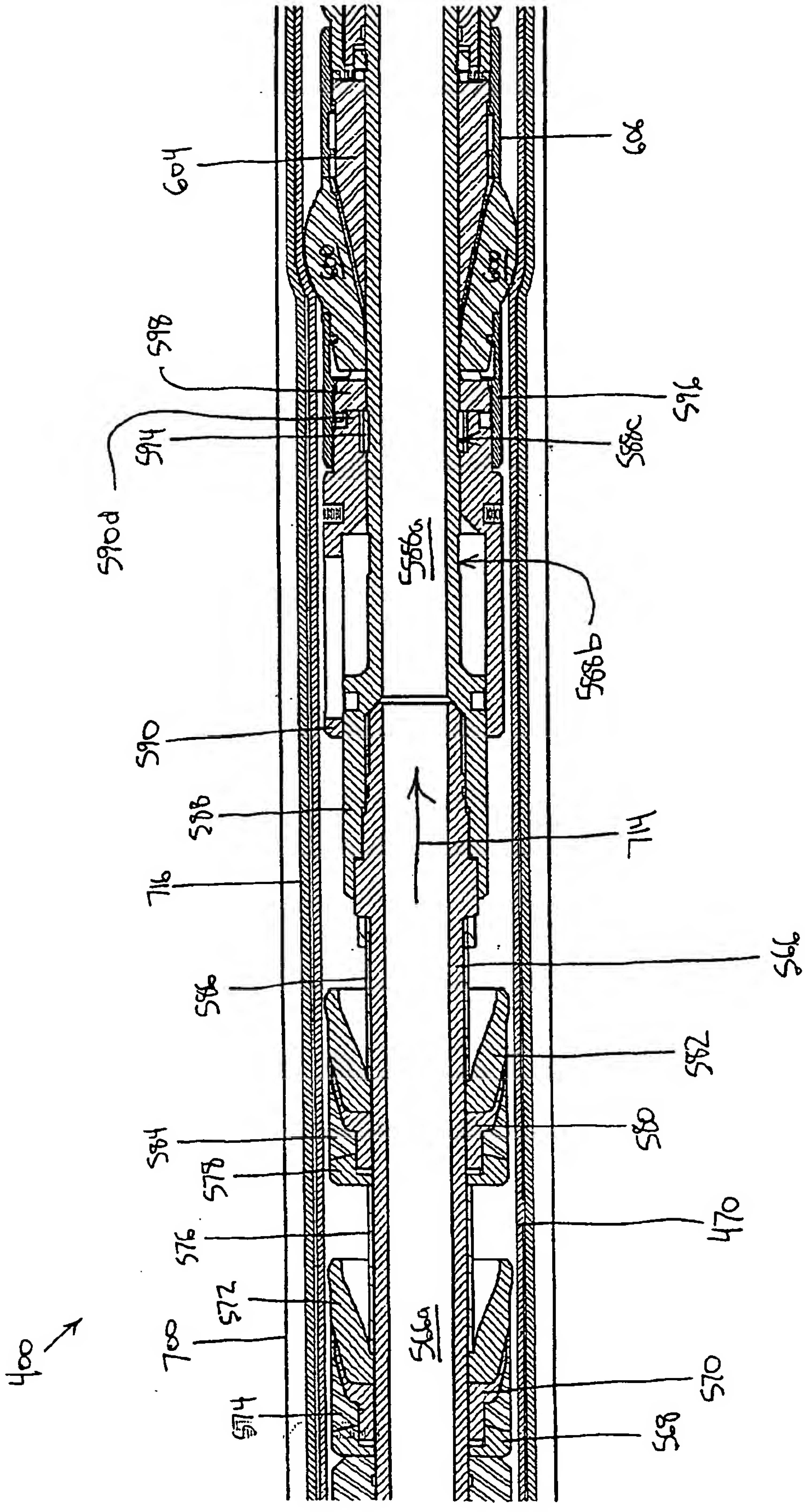
700
544
400

Fig. 34I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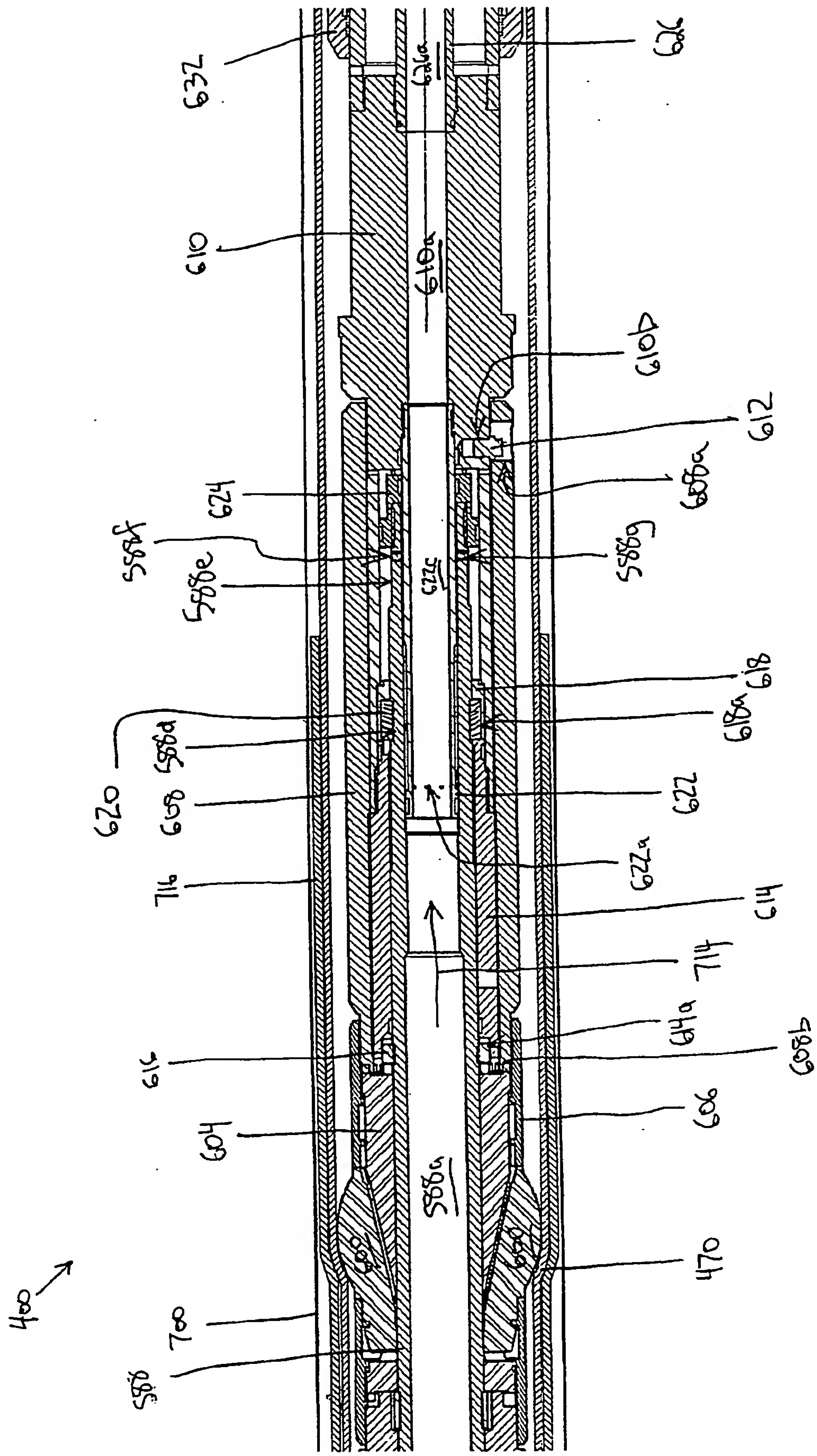
566a
700
400
574
570
568

Fig. 34J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616
608b
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588a
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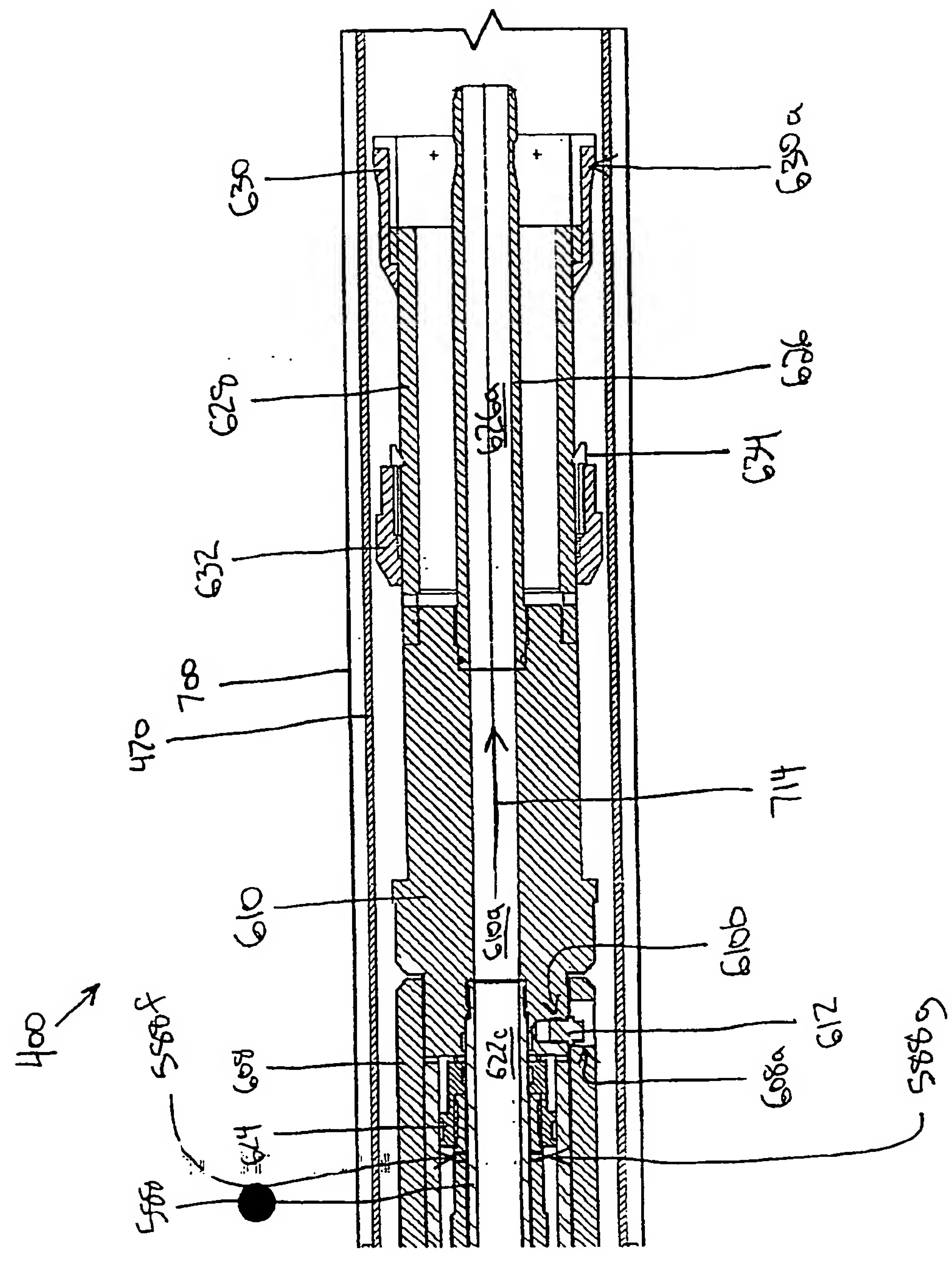
400
700
588

Fig. 34k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400
588f
588g
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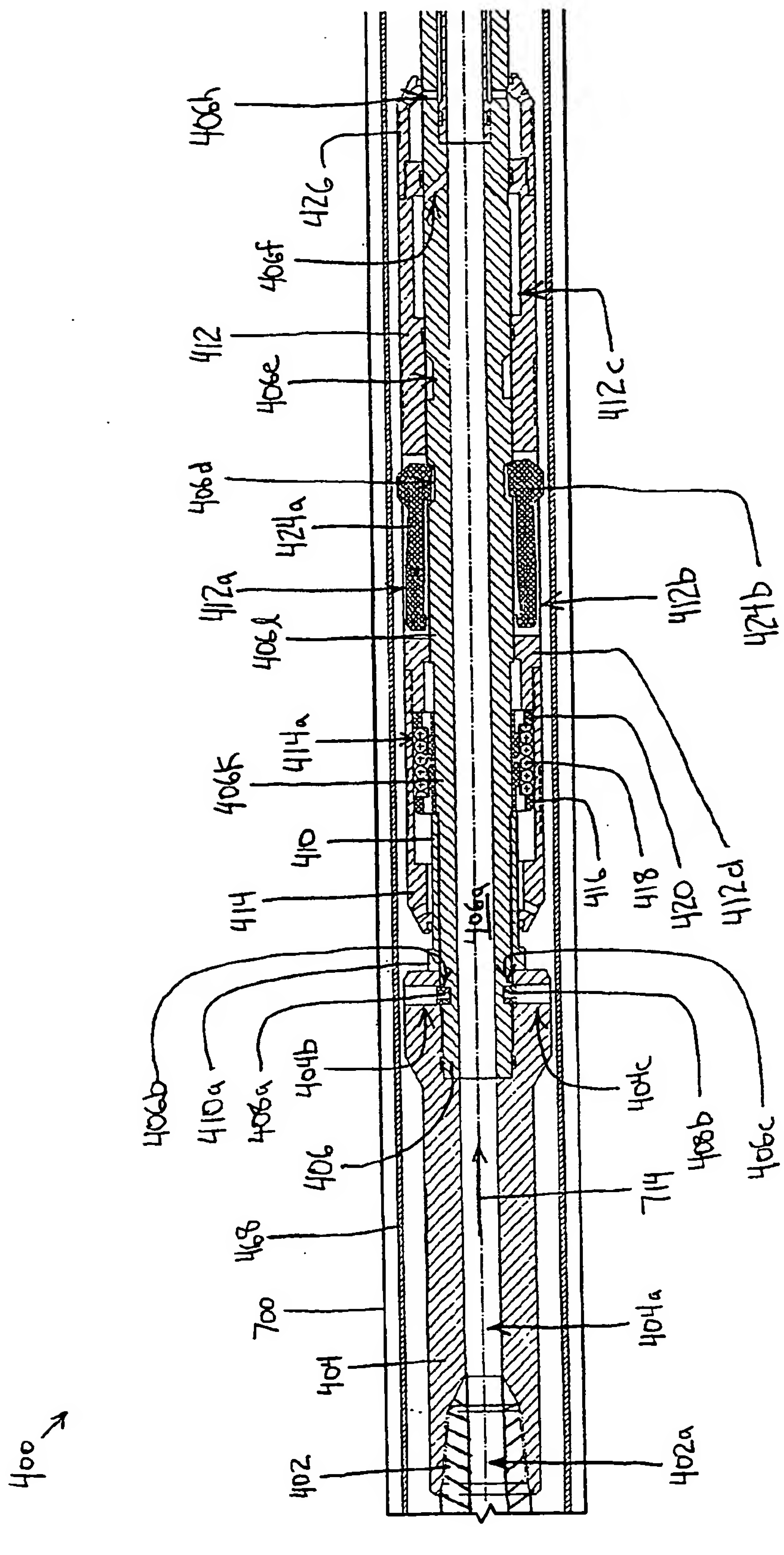
Fig. 34I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418
420
412d
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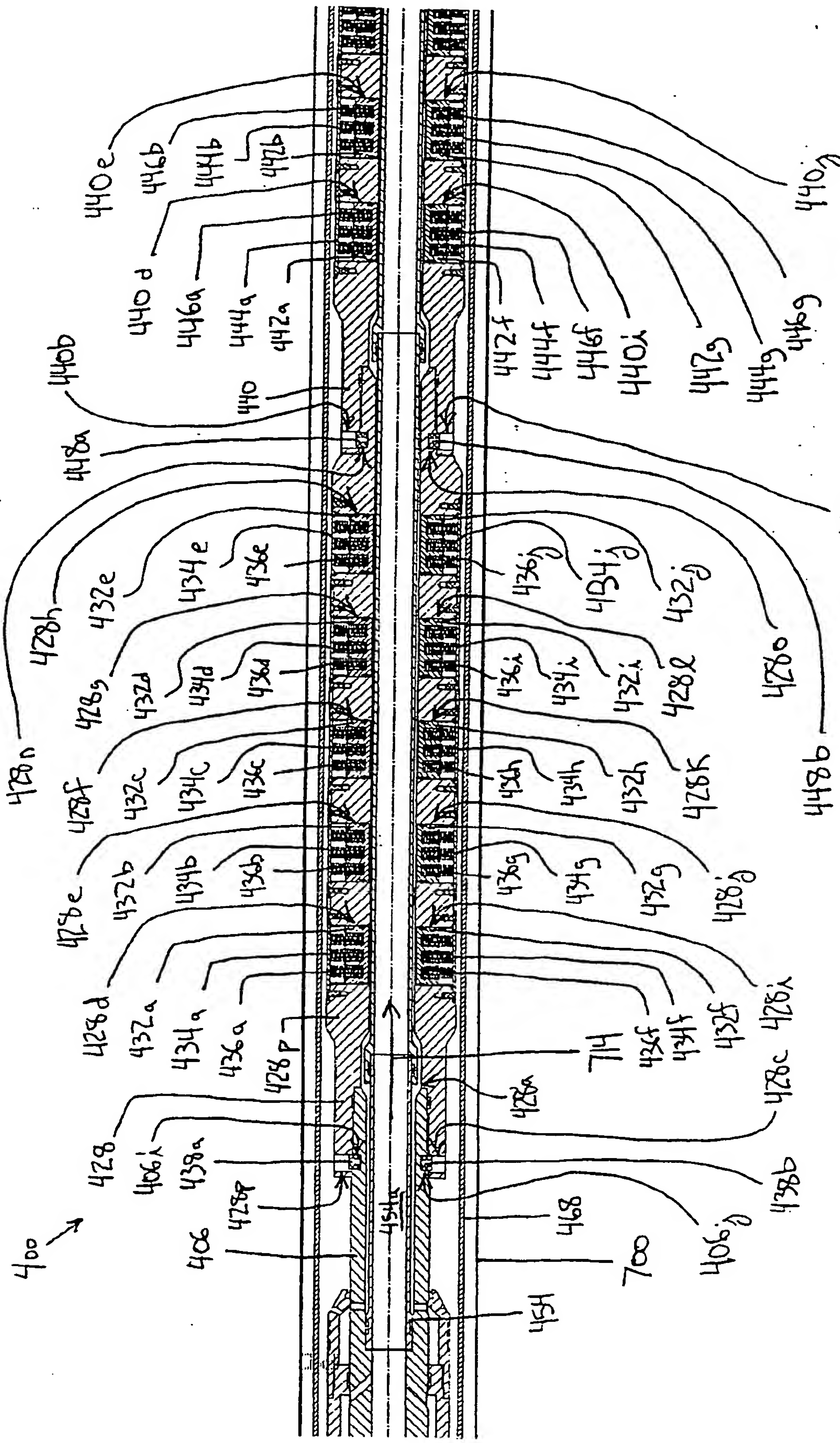
406d
406e
412
412c
406f
426
406h

Fig. 35a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436d
434d
432d
428g
436e
434e
432e
428h
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440b
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442a
444a
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440d
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446b
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440g
446g
444g
442g
440i
446f
444f
442f
440c
448b
428o
432j
434j
436j
428l
432i
434i
436i
428k
432h
434h
436h
428j
432g
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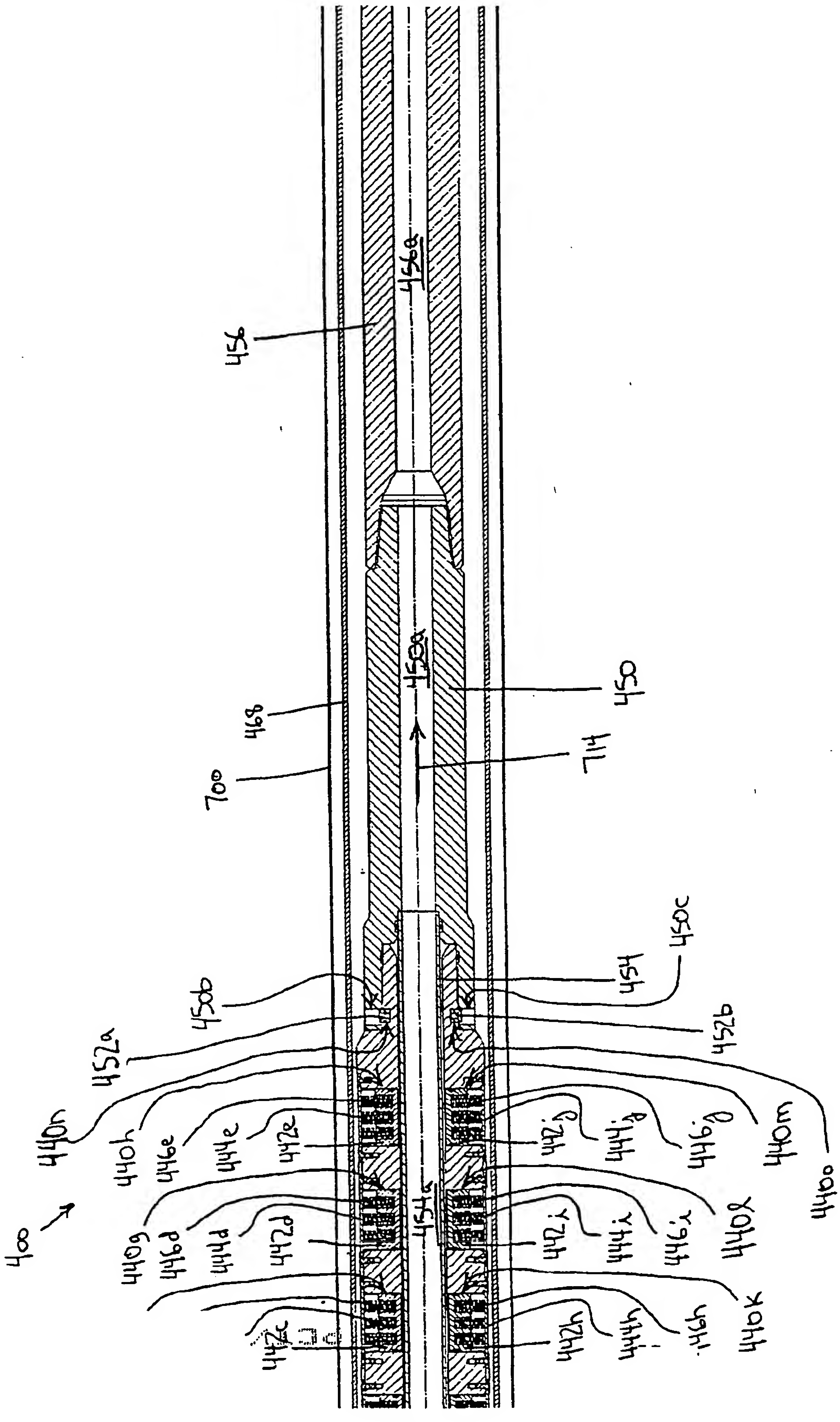
438b
406j
468
700
454

Fig. 35b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452b
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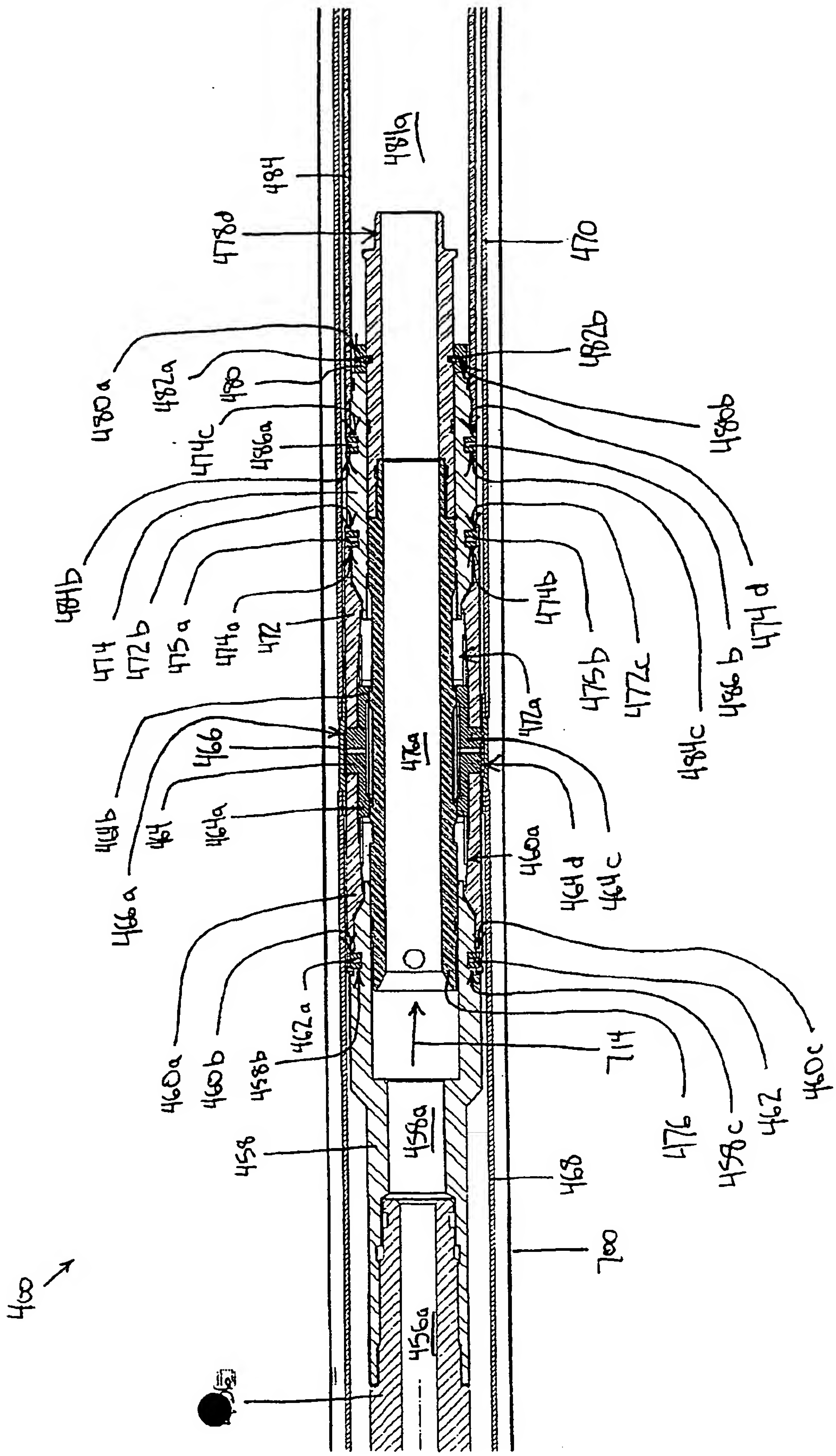
440m
440o
400
454a

Fig. 35c



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472c
484c
486b
474d
472a
476a
481b
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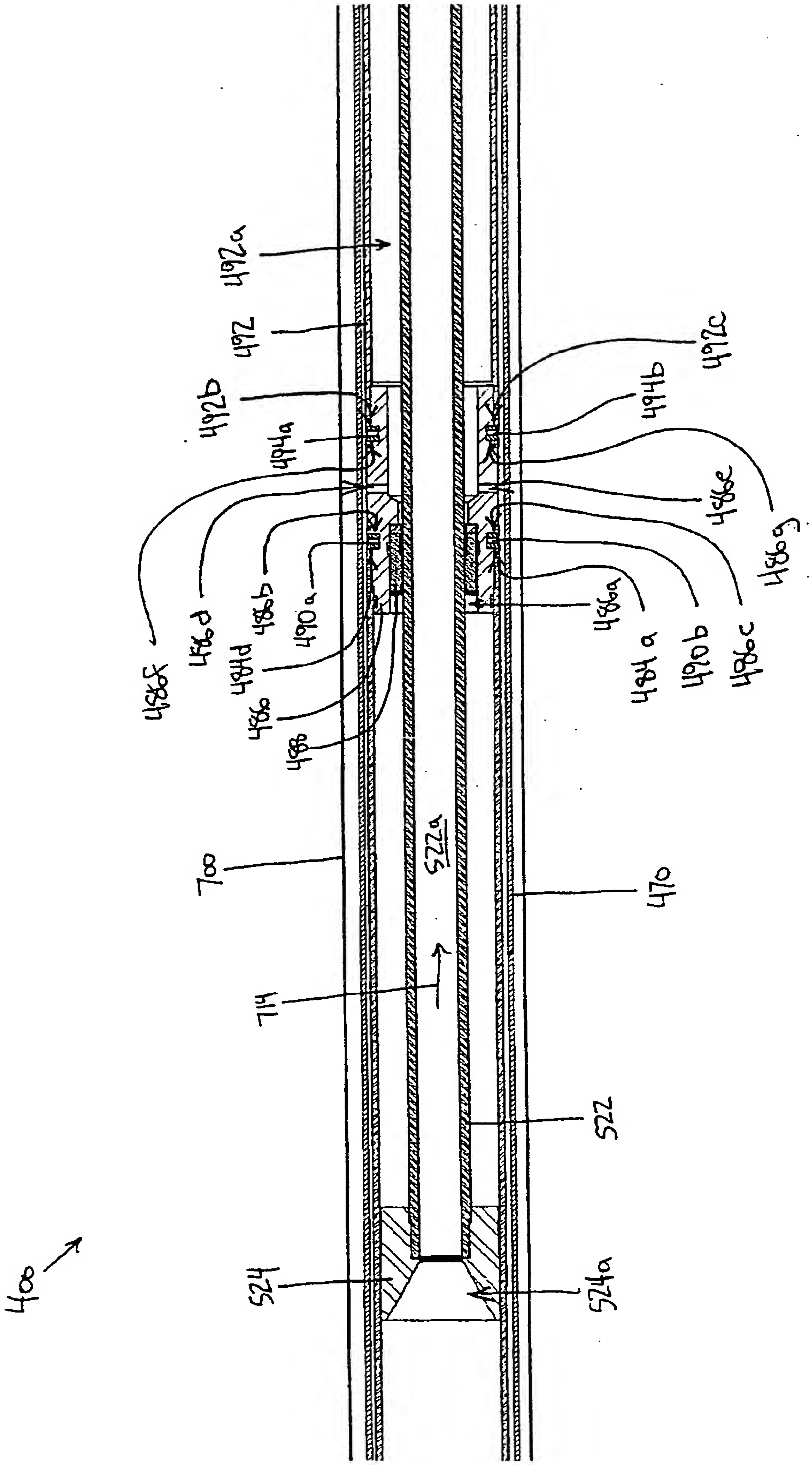
464
464a
466a
460a
464d
464c
460a
460b
458b
462a
714
476
458c
462
460c
458
458a
468
700
456a

Fig. 35d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486c
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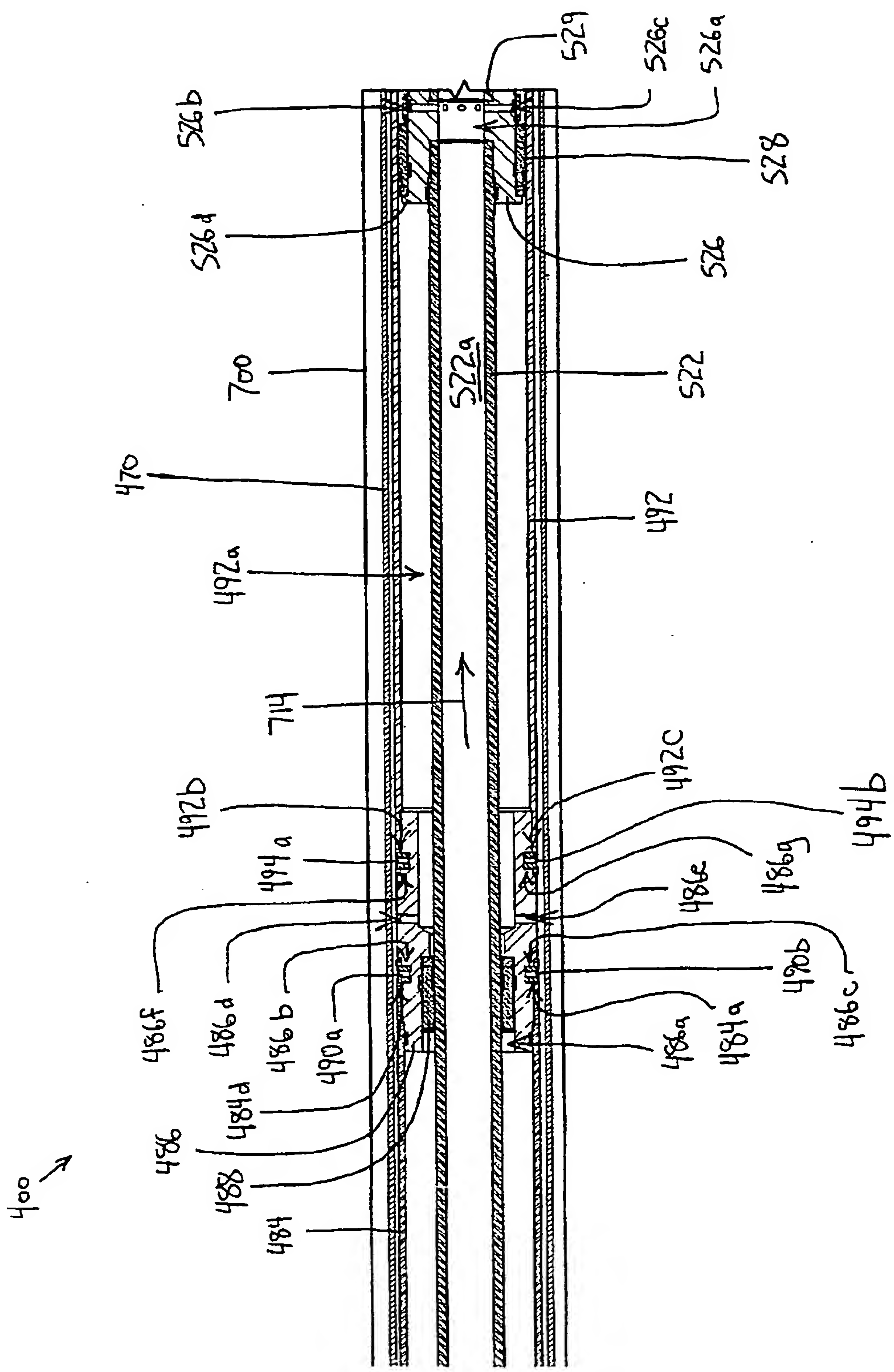
524a

Fig. 35e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490b
486c
484a
486a

Fig. 351

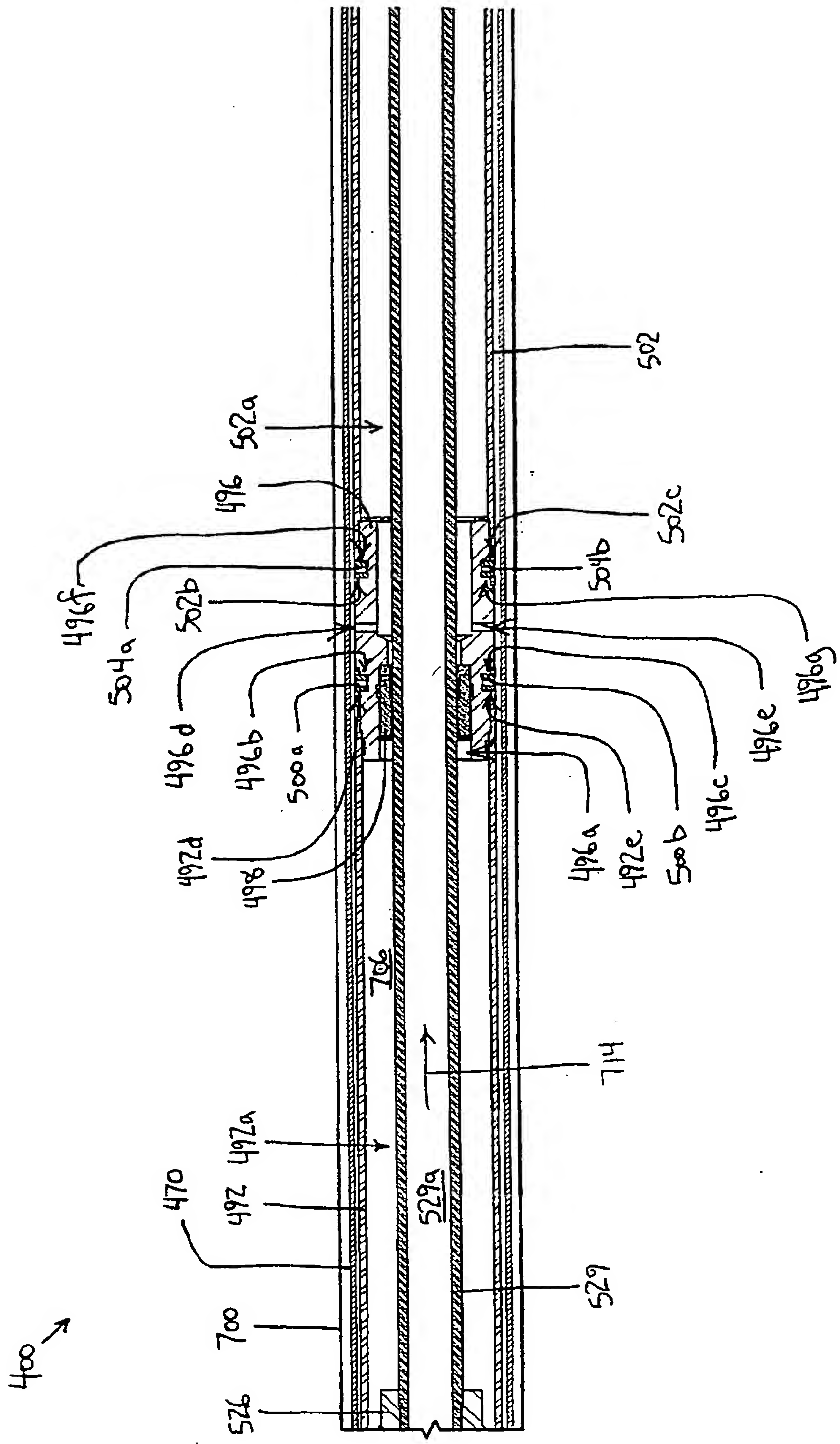
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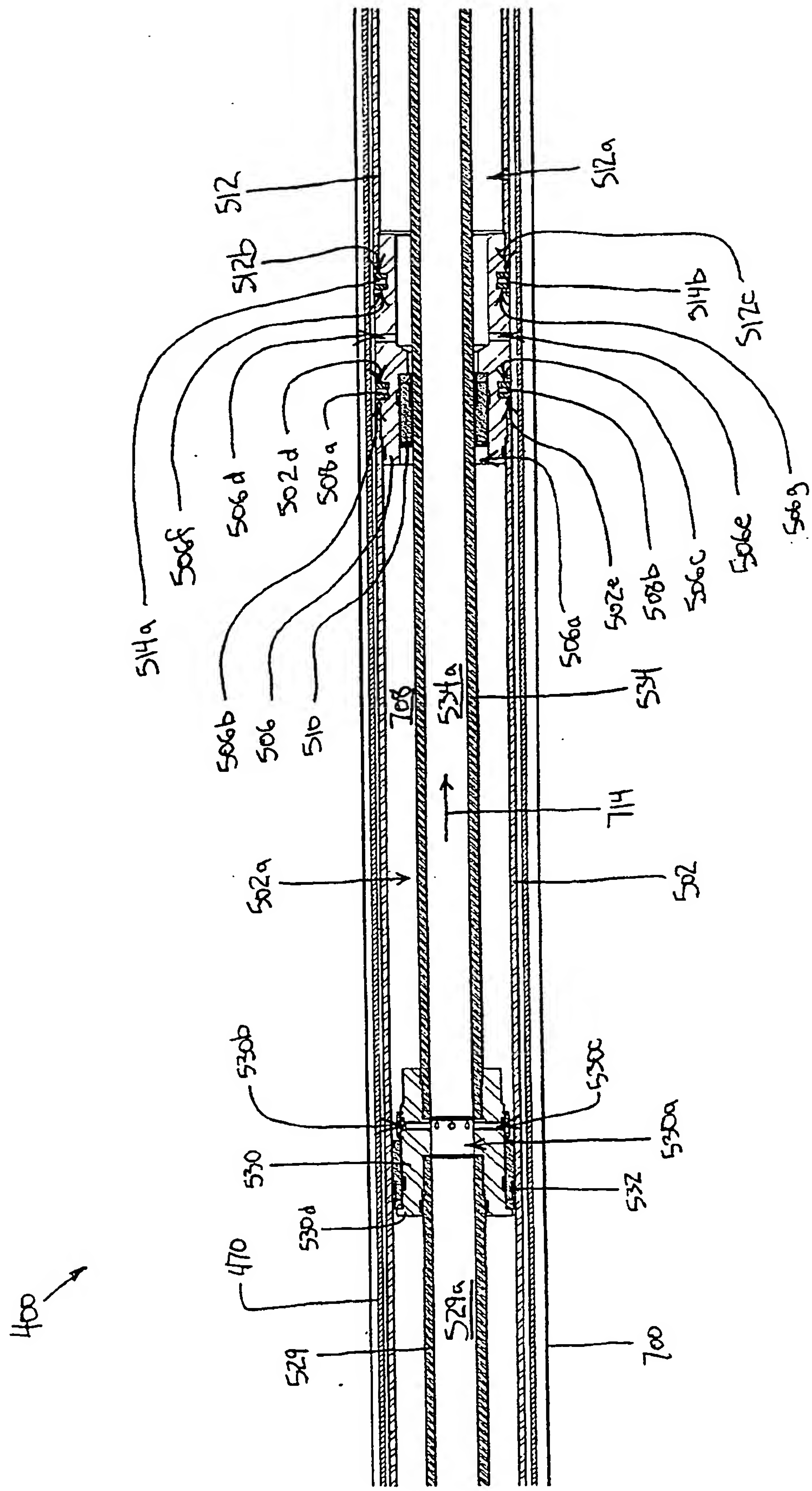
Fig. 35g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510
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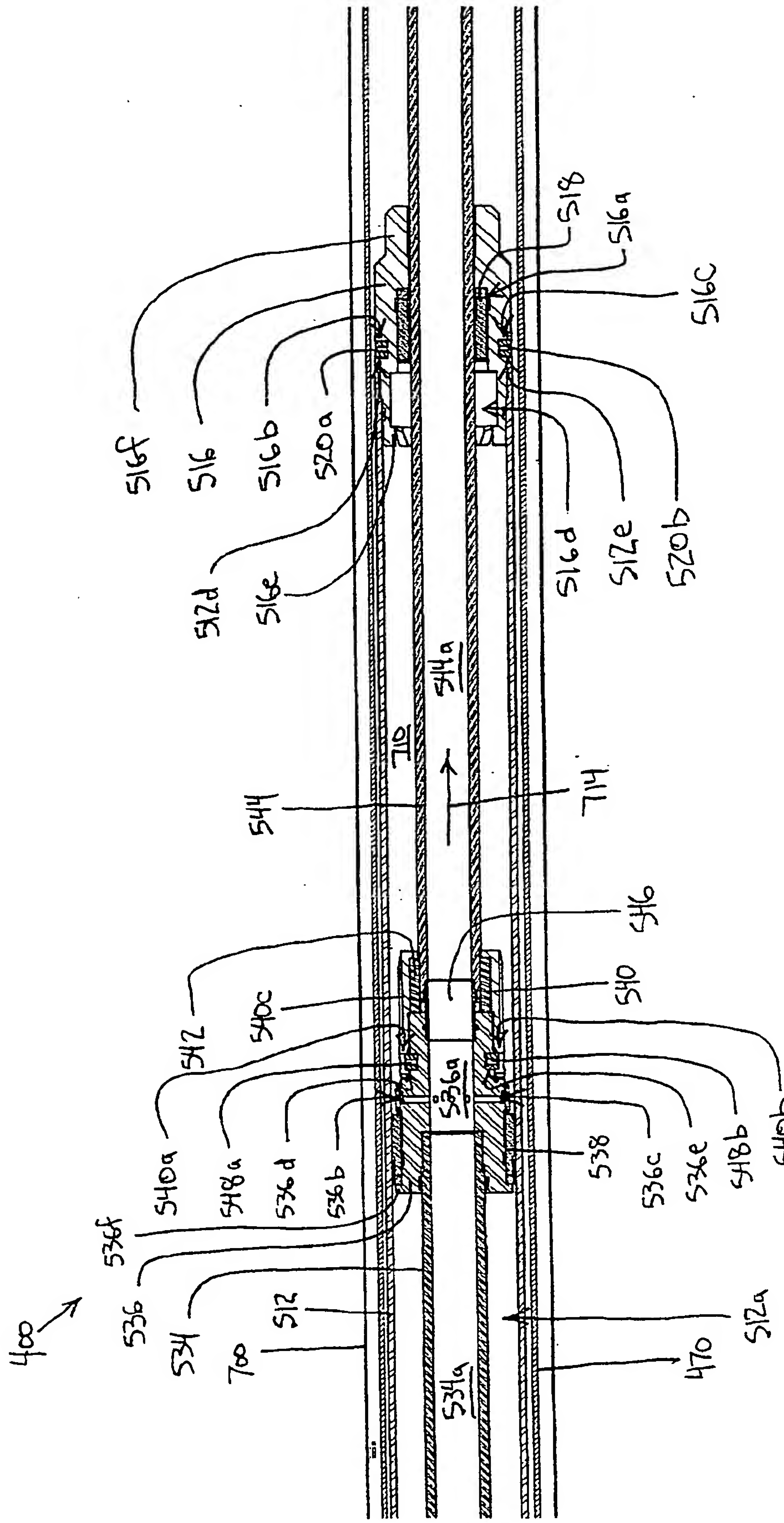
700

Fig. 35h



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512
540a
548a
536d
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470
534a

Fig. 35I

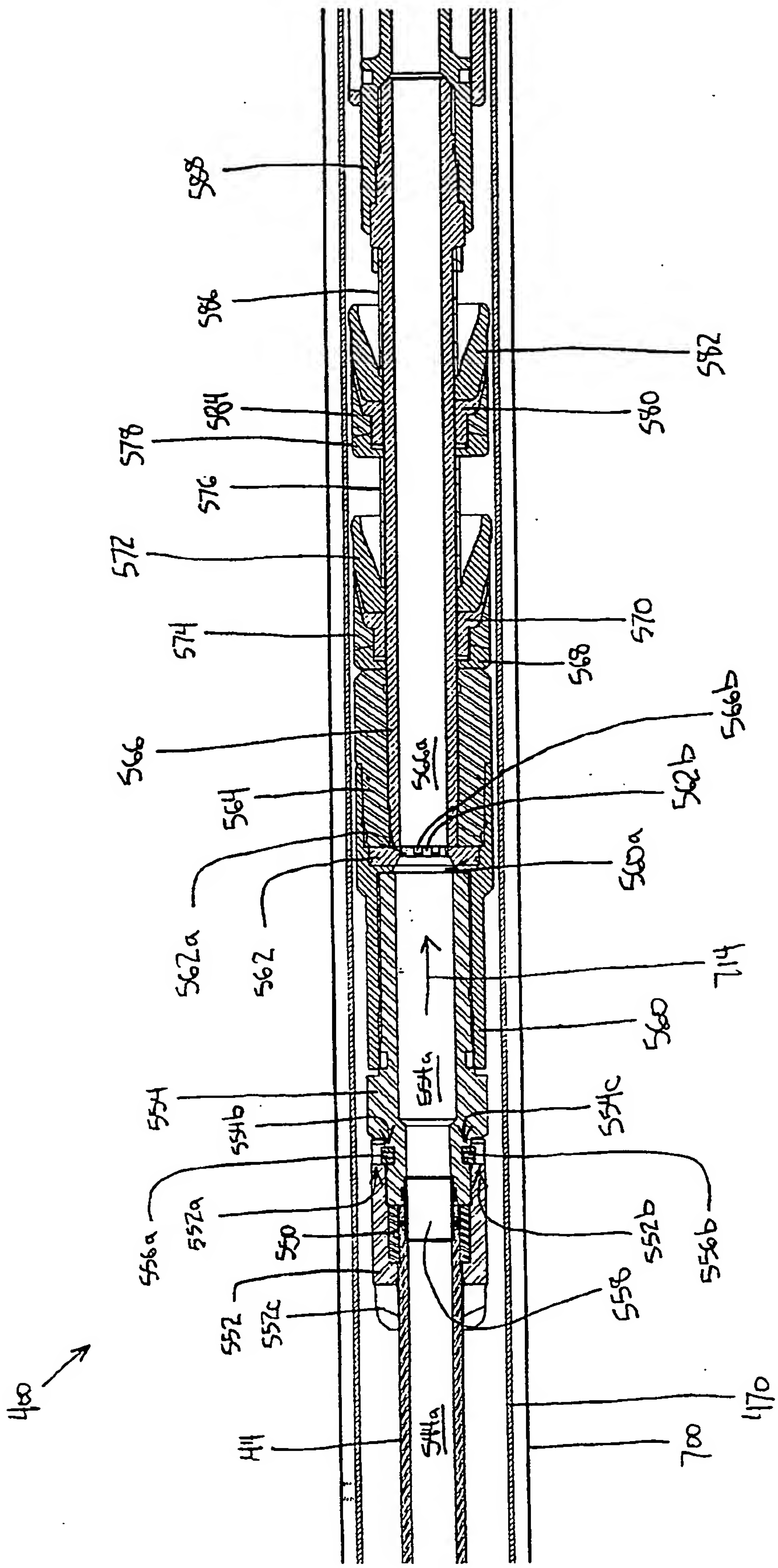
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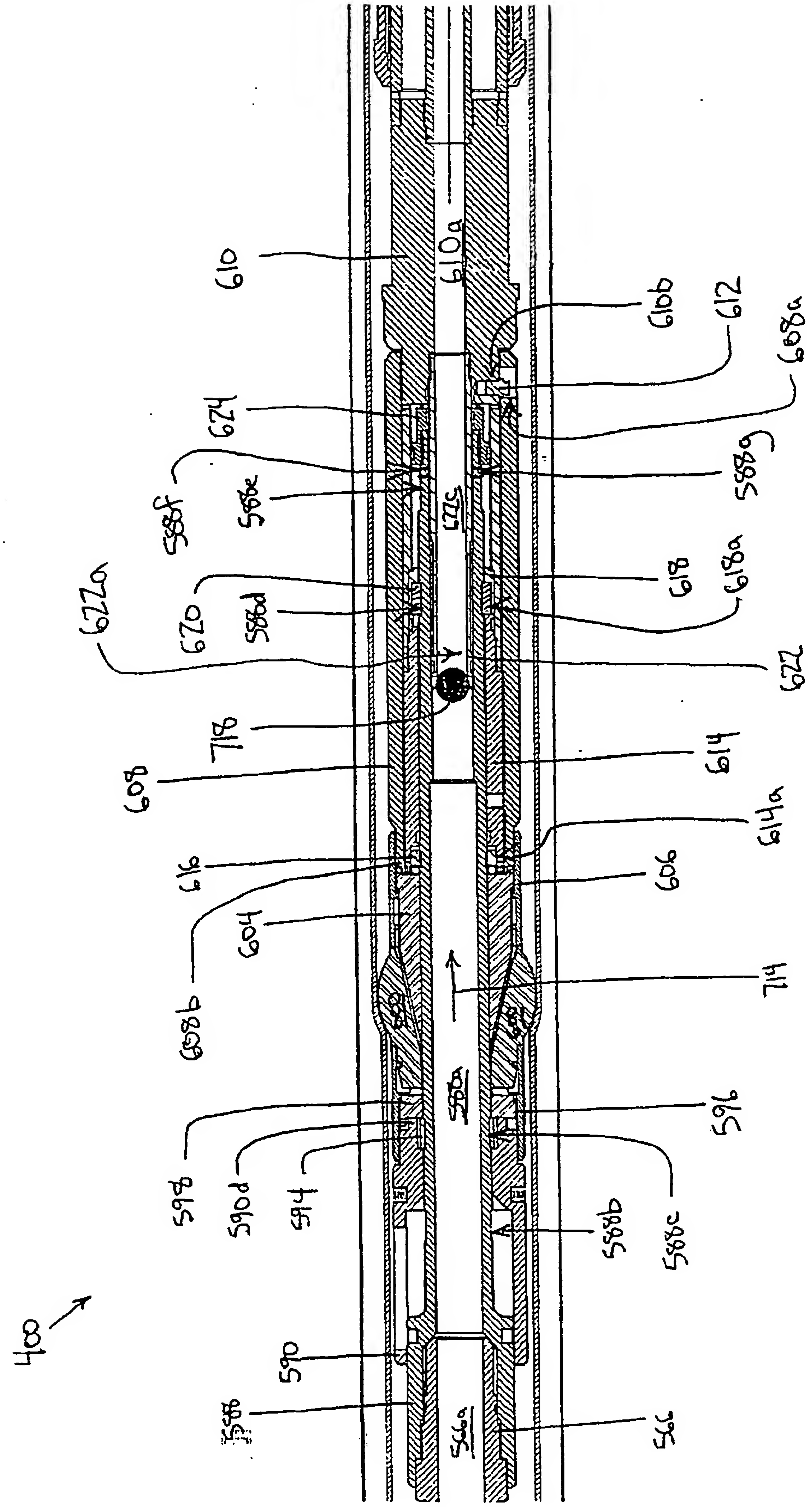
Fig. 35J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614
614a
616
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566a
556

Fig. 35k

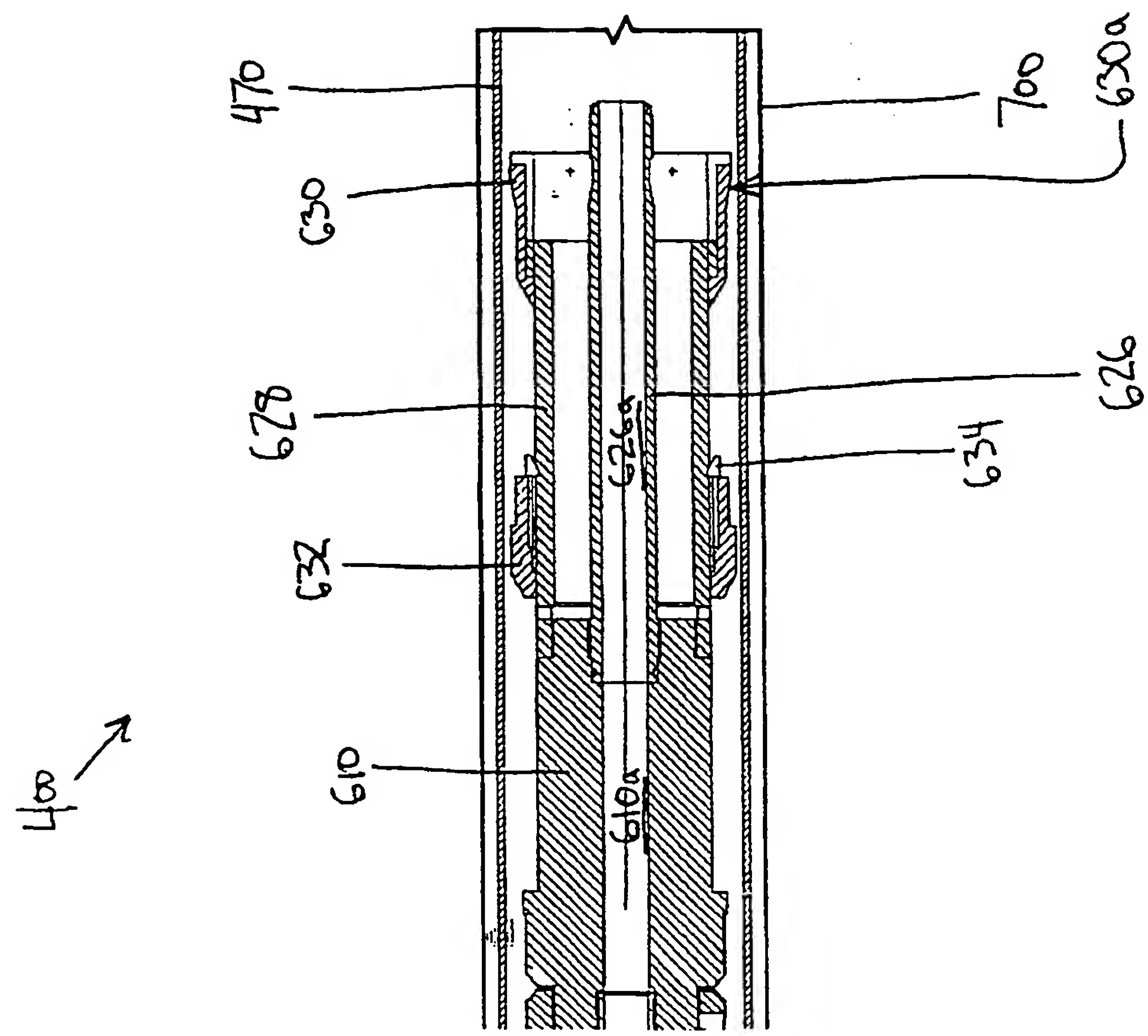
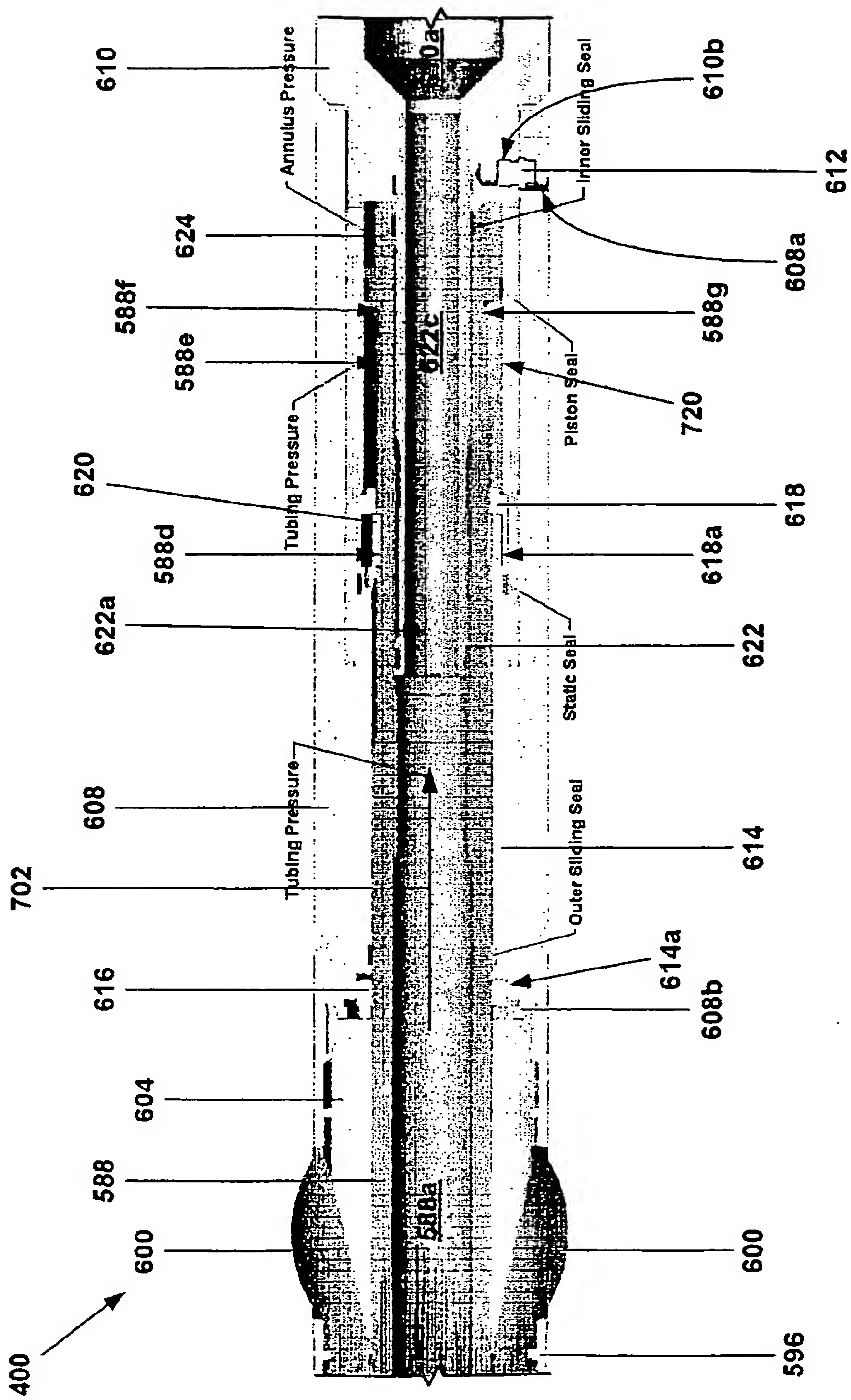


Fig. 35I



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622a
588d
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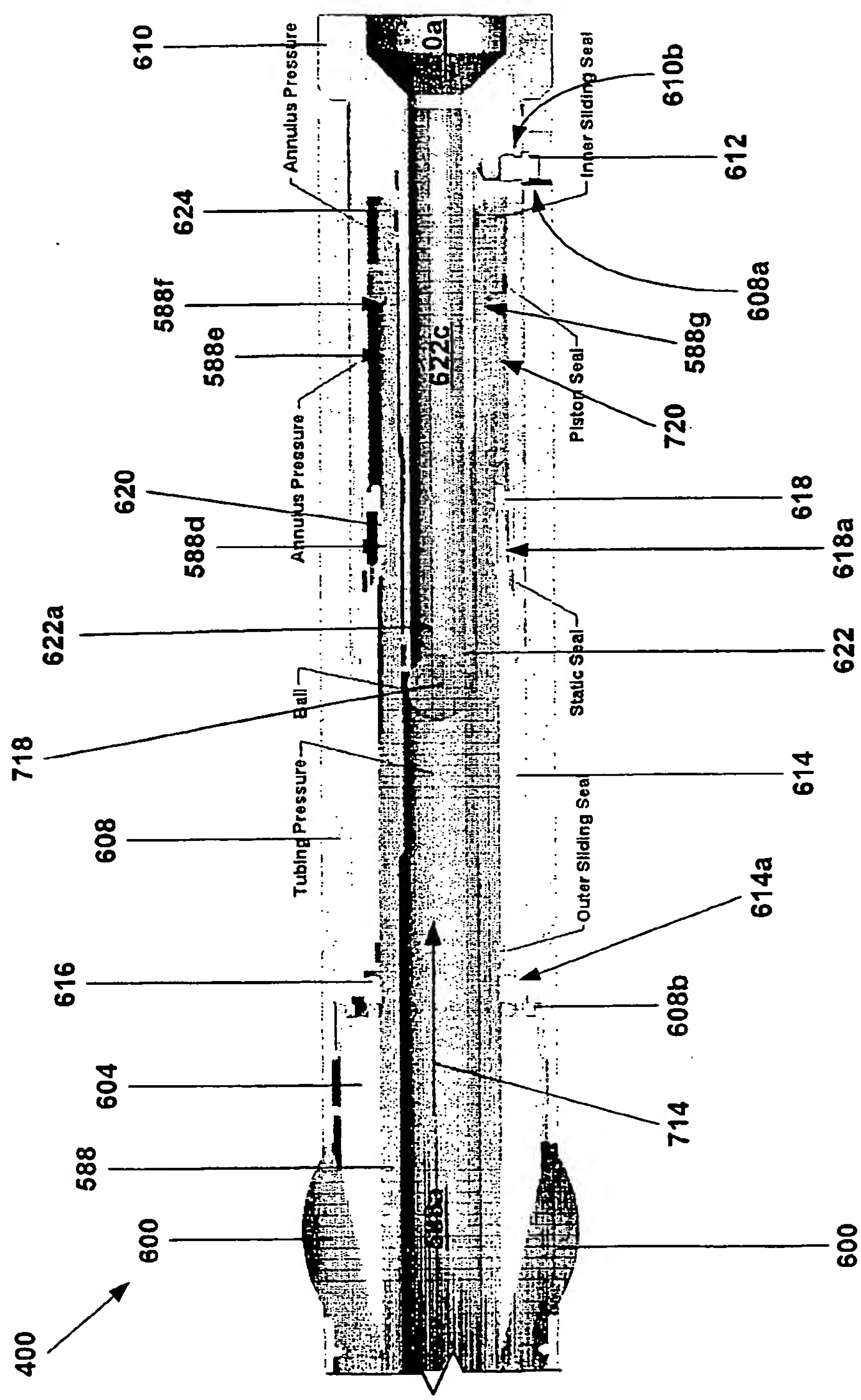
588f
624
610
Annulus Pressure
Tubing Pressure
Tubing Pressure
588a
Inner Sliding Seal
610b
612
608a
588g
720
Piston Seal
618
618a
Static Seal
622
Outer Sliding Seal
614
614a
608b
600
596

Fig. 36a



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Annulus Pressure
Inner Sliding Seal
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588d
618a
622a
Static Seal
622
Ball
718
Tubing Pressure
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608
Outer Sliding Seal
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616
608b
604
714
588
600
600
400

Fig. 36b

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 May 2003 (22.05.2003)

PCT

(10) International Publication Number
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(51) International Patent Classification⁷: E21B 43/10

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(25) Filing Language: English

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(30) Priority Data:

60/339,013	12 November 2001 (12.11.2001)	US
60/338,996	12 November 2001 (12.11.2001)	US
60/363,829	13 March 2002 (13.03.2002)	US
60/387,961	12 June 2002 (12.06.2002)	US

(71) Applicant (*for all designated States except US*): ENVENTURE GLOBAL TECHNLOGY [US/US]; 16200 A Park Row, Houston, TX 77084 (US).

(72) Inventors; and

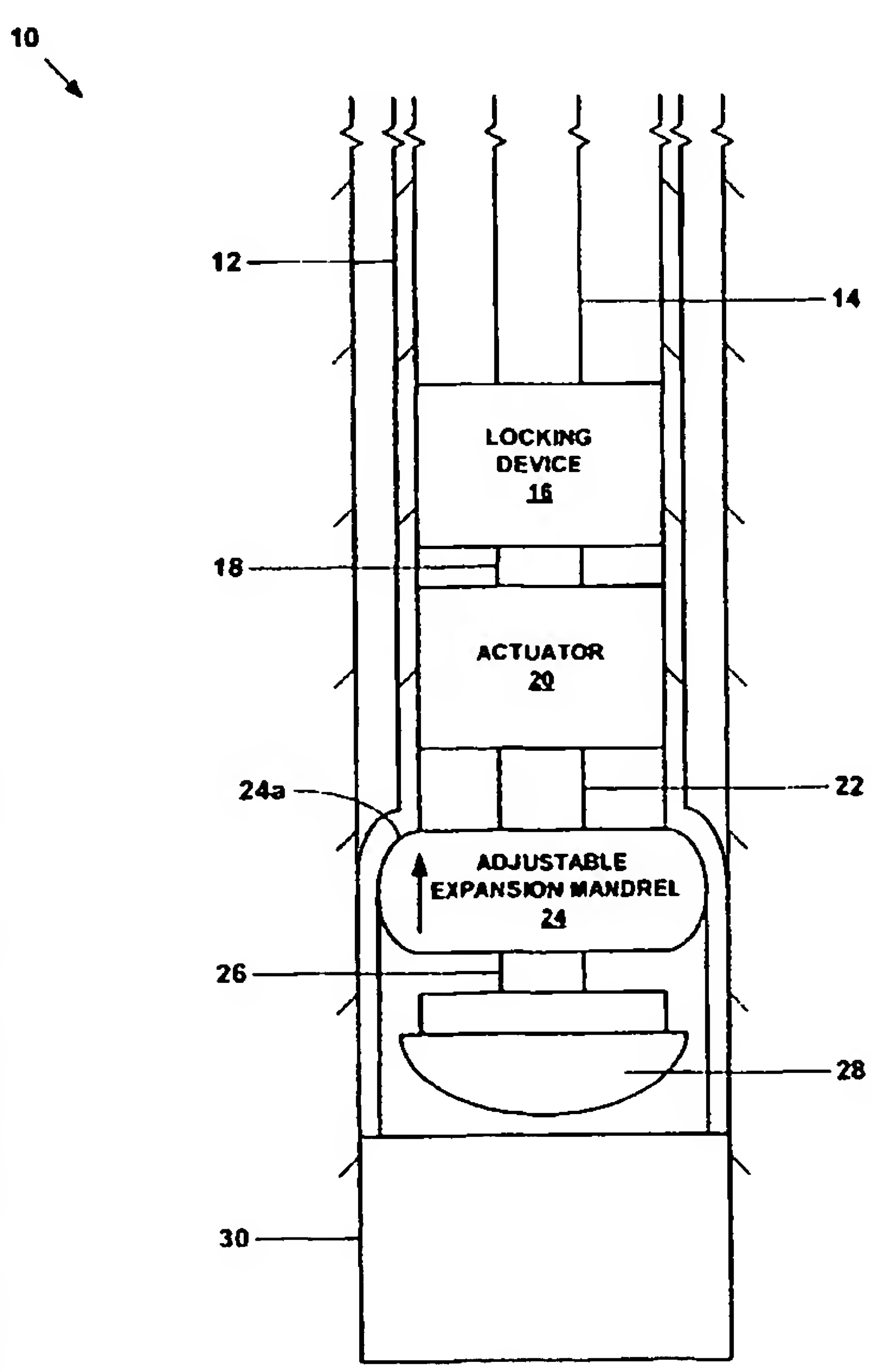
(75) Inventors/Applicants (*for US only*): RING, Lev [RU/US]; 14126 Heatherhill Place, Houston, TX 77077 (US). BRISCO, David, Paul [US/US]; 405 Westridge Drive, Duncan, OK 73533 (US). WATSON, Brock, Wayne [US/US]; 2535 Marsh Lane #1004, Carrollton, TX 75006 (US). WADDELL, Kevin, K. [US/US]; 11007 Sprucedale Court, Houston, TX 77070 (US).

(74) Agents: MATTINGLY, Todd et al.; Haynes and Boone, LLP, Suite 4300, 1000 Louisiana Street, Houston, TX 77002-5012 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK,

[Continued on next page]

(54) Title: MONO DIAMETER WELLBORE CASING



(57) Abstract: An apparatus (10) and method for forming a mono diameter wellbore casing (12).

WO 2003/042487 A3

SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) **Date of publication of the international search report:** 1 July 2004

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/36267

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : E21B 43/10
US CL : 166/207,277,382

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 166/121,182,202,207,212,216,217,242.8,277,382,387

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
East: (expan$4 with (tub$5 pip$3 casing$1 conduit$1))

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,785,193 A (KINLEY et al) 15 January 1974 (15.01.1974), see entire document, especially Figs. 1-3.	1,4,19,21
A	US 4,168,747 A (YOUMANS) 25 September 1979 (25.09.1979), see entire document, especially Fig. 1.	7,8
A	US 5,957,195 A (BAILEY et al) 28 September 1999 (28.09.1999), see entire document, especially Figs. 2-3.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 January 2003 (02.01.2003)	21 MAY 2004

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Zakiya N. Walker
Facsimile No. (703)305-3230	Telephone No. (703) 308-2168

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(43) International Publication Date
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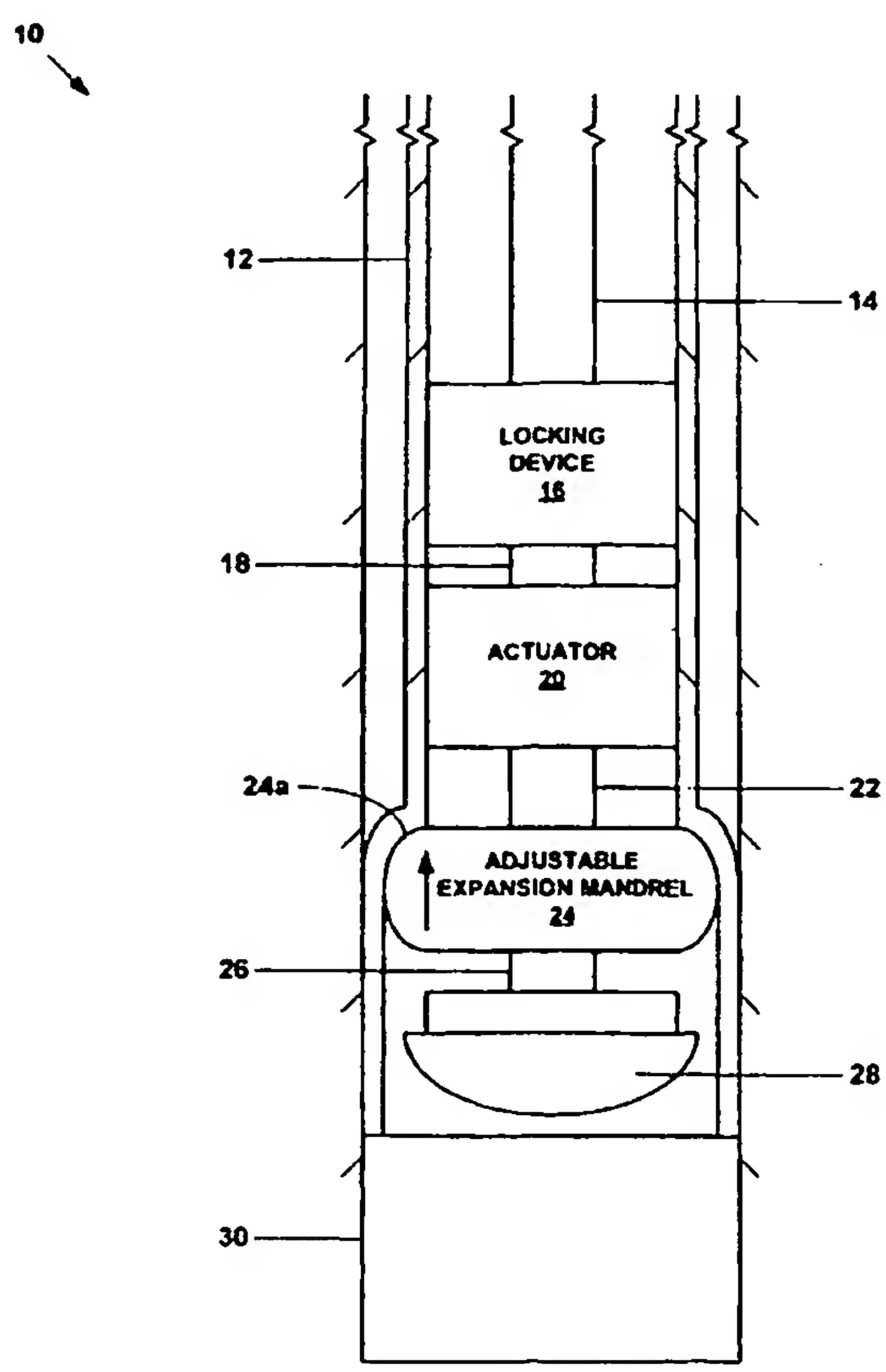
(75) Inventors/Applicants (*for US only*): RING, Lev [RU/US]; 14126 Heatherhill Place, Houston, TX 77077 (US). BRISCO, David, Paul [US/US]; 405 Westridge Drive, Duncan, OK 73533 (US). WATSON, Brock, Wayne [US/US]; 2535 Marsh Lane #1004, Carrollton, TX 75006 (US). WADDELL, Kevin, K. [US/US]; 11007 Sprucedale Court, Houston, TX 77070 (US).

(74) Agents: MATTINGLY, Todd et al.; Haynes and Boone, LLP, Suite 4300, 1000 Louisiana Street, Houston, TX 77002-5012 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK,

[Continued on next page]

(54) Title: MONO DIAMETER WELLBORE CASING



(57) Abstract: An apparatus (10) and method for forming a mono diameter wellbore casing (12).

WO 2003/042487 A3

SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*
— *with amended claims*

(88) Date of publication of the international search report: 1 July 2004

Date of publication of the amended claims: 26 August 2004

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AMENDED CLAIMS
[received by the International Bureau on 16 July 2004 (16.07.04);
original claims 1-38 amended, claims 39-204 added]

Claims

What is claimed is:

1. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device.

2. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

3. A method for forming a mono diameter wellbore casing, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

4. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;

a support member coupled to the locking device; and

a sealing member for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during radial expansion of the expandable tubular member.

5. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

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supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole; and

pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

6. A method for forming a mono diameter wellbore casing, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;

pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the second

expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole; and

pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

7. An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

a drilling member coupled to the float shoe adapted to drill the borehole;

an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;

an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device.

8. A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;

coupling a drilling member to an end of the expandable tubular member;

drilling the borehole using the drilling member;

positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;

lowering the adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole.

9. A method for forming a mono diameter wellbore casing within a borehole, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

coupling a drilling member to an end of the first expandable tubular member;

drilling a first section of the borehole using the drilling member;

supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

coupling the drilling member to an end of the second expandable tubular member;

drilling a second section of the borehole using the drilling member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole.

10. An apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;
a drilling member coupled to the float shoe adapted to drill the borehole;
an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension;
an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member;
a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;
a support member coupled to the locking device; and
a sealing member for sealing engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during the radial expansion of the expandable tubular member.

11. A method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

positioning an adjustable expansion mandrel within the expandable tubular member;
coupling a drilling member to an end of the expandable tubular member;
drilling the borehole using the drilling member;
positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;
lowering the adjustable expansion mandrel out of the expandable tubular member;
increasing the outside dimension of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole; and
pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

12. A method for forming a mono diameter wellbore casing within a borehole, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

coupling a drilling member to an end of the first expandable tubular member;

drilling a first section of the borehole using the drilling member;

supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;

lowering the adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;

pressuring an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole;

positioning the adjustable expansion mandrel within a second expandable tubular member;

coupling the drilling member to an end of the second expandable tubular member;

drilling a second section of the borehole using the drilling member;

supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;

lowering the adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the adjustable expansion mandrel;

displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole; and

pressuring an interior portion of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic

deformation of the second expandable tubular member within the drilled second section of the borehole.

13. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension;

a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension;

an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member; and

a support member coupled to the locking device;

wherein the first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

14. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning first and second adjustable expansion mandrels within the expandable tubular member;

supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

lowering the first adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the expandable

tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

15. A method for forming a mono diameter wellbore casing, comprising:

positioning first and second adjustable expansion mandrels within a first expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

lowering the first adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the

expandable tubular member;

positioning first and second adjustable expansion mandrels within a second expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

lowering the first adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel; and

displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

16. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a float shoe adapted to mate with an end of the expandable tubular member;

a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension;

a second adjustable expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside

dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension;

an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the expandable tubular member;

a locking device coupled to the actuator adapted to controllably engage the expandable tubular member;

a support member coupled to the locking device; and

a sealing member for sealingly engaging the expandable tubular adapted to define a pressure chamber above the first and second adjustable expansion mandrels during the radial expansion of the expandable tubular member;

wherein the first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.

17. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

positioning first and second adjustable expansion mandrels within the expandable tubular member;

supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

lowering the first adjustable expansion mandrel out of the expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

pressurizing an interior region of the expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion

mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member, and

pressurizing an interior region of the expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the expandable tubular member above the lower portion of the expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

18. A method for forming a mono diameter wellbore casing, comprising:

positioning first and second adjustable expansion mandrels within a first expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

lowering the first adjustable expansion mandrel out of the first expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

pressurizing an interior region of the first expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the first expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the first

expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member;

pressurizing an interior region of the first expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the first expandable tubular member above the lower portion of the first expandable tubular member by the second adjustable expansion mandrel;

positioning first and second adjustable expansion mandrels within a second expandable tubular member;

supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

lowering the first adjustable expansion mandrel out of the second expandable tubular member;

increasing the outside dimension of the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

pressurizing an interior region of the second expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the second expandable tubular member by the first adjustable expansion mandrel;

displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member; and

pressurizing an interior region of the second expandable tubular member above the

second adjustable expansion mandrel during the radial expansion of the portions of the second expandable tubular member above the lower portion of the second expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

19. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

a locking device coupled to the support member and releasably coupled to the expandable tubular member;

an adjustable expansion mandrel adapted to be controllably expanded to a larger outside dimension for radial expansion and plastic deformation of the expandable tubular member or collapsed to a smaller outside dimension; and

an actuator coupled to the locking member and the adjustable expansion mandrel adapted to displace the adjustable expansion mandrel upwardly through the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

20. The apparatus of claim 19, further comprising:

a gripping assembly coupled to the support member and the actuator for controllably gripping at least one of the expandable tubular member or another tubular member.

21. The apparatus of claim 19, further comprising:

one or more cup seals coupled to the support member for sealingly engaging the expandable tubular member above the adjustable expansion mandrel.

22. The apparatus of claim 19, further comprising:

an expansion mandrel coupled to the adjustable expansion mandrel; and

a float collar assembly coupled to the adjustable expansion mandrel comprising:

a float valve assembly; and

a sealing sleeve coupled to the float valve assembly adapted to be radially expanded and plastically deformed by the expansion mandrel.

23. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;

increasing the size of the adjustable expansion mandrel; and

displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

24. The method of claim 23, further comprising:

reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed.

25. The method of claim 24, further comprising:

fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

26. The method of claim 25, further comprising:

permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

27. The method of claim 26, further comprising:

injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

28. The method of claim 26, further comprising:

increasing the size of the adjustable expansion mandrel after permitting the position

of the expandable tubular member to float relative to the position of the hydraulic actuator.

29. The method of claim 28, further comprising:
displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

30. The method of claim 29, further comprising:
if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then
not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

31. A method for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing, comprising:
supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;
increasing the size of the adjustable expansion mandrel;
displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member; and
displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

32. The method of claim 31, further comprising:
reducing the size of the adjustable expansion mandrel after the portion of the

expandable tubular member has been radially expanded and plastically deformed.

33. The method of claim 32, further comprising:
fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

34. The method of claim 33, further comprising:
permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

35. The method of claim 34, further comprising:
injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

36. The method of claim 34, further comprising:
increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

37. The method of claim 36, further comprising:
displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member.

38. The method of claim 37, further comprising:
not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that

overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

39. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

an expansion device for radially expanding and plastically deforming the tubular member coupled to the support member; and

an actuator coupled to the support member for displacing the expansion device relative to the support member.

40. The apparatus of claim 39, further comprising:

a gripping device for gripping the tubular member coupled to the support member.

41. The apparatus of claim 40, wherein the gripping device comprises a plurality of movable gripping elements.

42. The apparatus of claim 41, wherein the gripping elements are moveable in a radial direction relative to the support member.

43. The apparatus of claim 39, further comprising:

a sealing device for sealing an interface with the tubular member coupled to the support member.

44. The apparatus of claim 43, wherein the sealing device seals an annulus defines between the support member and the tubular member.

45. The apparatus of claim 39, further comprising:

a locking device for locking the position of the tubular member relative to the support member.

46. The apparatus of claim 45, wherein the locking device comprises:

a pressure sensor for controllably unlocking the locking device from engagement with the

tubular member when the operating pressure within the apparatus exceeds a predetermined amount.

47. The apparatus of claim 45, wherein the locking device comprises:
a position sensor for controllably unlocking the locking device from engagement with the tubular member when the position of the actuator exceeds a predetermined amount.

48. The apparatus of claim 39, wherein the expansion device comprises:
a support member; and
a plurality of movable expansion elements coupled to the support member.

49. The apparatus of claim 48, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

50. The apparatus of claim 49, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

51. The apparatus of claim 50, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

52. The apparatus of claim 50, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

53. The apparatus of claim 39, wherein the expansion device comprises an adjustable expansion device.

54. The apparatus of claim 39, wherein the expansion device comprises a plurality of

expansion devices.

55. The apparatus of claim 54, wherein at least one of the expansion devices comprises an adjustable expansion device.

56. The apparatus of claim 55, wherein the adjustable expansion device comprises:
a support member; and
a plurality of movable expansion elements coupled to the support member.

57. The apparatus of claim 56, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

58. The apparatus of claim 57, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

59. The apparatus of claim 58, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

60. The apparatus of claim 58, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

61. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
a support member;
an expansion device for radially expanding and plastically deforming the tubular member coupled to the support member; and
a sealing assembly for sealing an annulus defined between the support member and

the tubular member.

62. The apparatus of claim 61, further comprising:
a gripping device for gripping the tubular member coupled to the support member.

63. The apparatus of claim 62, wherein the gripping device comprises a plurality of movable gripping elements.

64. The apparatus of claim 63, wherein the gripping elements are moveable in a radial direction relative to the support member.

65. The apparatus of claim 61, further comprising:
a locking device for locking the position of the tubular member relative to the support member.

66. The apparatus of claim 65, wherein the locking device comprises:
a pressure sensor for controllably unlocking the locking device from engagement with the tubular member when the operating pressure within the apparatus exceeds a predetermined amount.

67. The apparatus of claim 65, wherein the locking device comprises:
a position sensor for controllably unlocking the locking device from engagement with the tubular member when the position of a portion of the apparatus exceeds a predetermined amount.

68. The apparatus of claim 61, further comprising:
an actuator for displacing the expansion device relative to the support member.

69. The apparatus of claim 68, wherein the actuator comprises means for transferring torsional loads between the support member and the expansion device.

70. The apparatus of claim 68, wherein the actuator comprises a plurality of pistons positioned within corresponding piston chambers.

71. The apparatus of claim 61, wherein the expansion device comprises:
a support member; and
a plurality of movable expansion elements coupled to the support member.

72. The apparatus of claim 71, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

73. The apparatus of claim 72, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

74. The apparatus of claim 73, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

75. The apparatus of claim 73, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

76. The apparatus of claim 61, wherein the expansion device comprises an adjustable expansion device.

77. The apparatus of claim 61, wherein the expansion device comprises a plurality of expansion devices.

78. The apparatus of claim 77, wherein at least one of the expansion devices comprises an adjustable expansion device.

79. The apparatus of claim 78, wherein the adjustable expansion device comprises:
a support member; and

a plurality of movable expansion elements coupled to the support member.

80. The apparatus of claim 79, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

81. The apparatus of claim 80, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

82. The apparatus of claim 81, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

83. The apparatus of claim 81, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

84. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
a support member;
a first expansion device for radially expanding and plastically deforming the tubular member coupled to the support member; and
a second expansion device for radially expanding and plastically deforming the tubular member coupled to the support member.

85. The apparatus of claim 84, further comprising:
a gripping device for gripping the tubular member coupled to the support member.

86. The apparatus of claim 85, wherein the gripping device comprises a plurality of movable gripping elements.

87. The apparatus of claim 86, wherein the gripping elements are moveable in a radial direction relative to the support member.

88. The apparatus of claim 84, further comprising:
a sealing device for sealing an interface with the tubular member coupled to the support member.

89. The apparatus of claim 88, wherein the sealing device seals an annulus defines between the support member and the tubular member.

90. The apparatus of claim 84, further comprising:
a locking device for locking the position of the tubular member relative to the support member.

91. The apparatus of claim 90, wherein the locking device comprises:
a pressure sensor for controllably unlocking the locking device from engagement with the tubular member when the operating pressure within the apparatus exceeds a predetermined amount.

92. The apparatus of claim 90, wherein the locking device comprises:
a position sensor for controllably unlocking the locking device from engagement with the tubular member when the position of a portion of the apparatus exceeds a predetermined amount.

93. The apparatus of claim 84, further comprising:
an actuator for displacing the expansion device relative to the support member.

94. The apparatus of claim 93, wherein the actuator comprises means for transferring torsional loads between the support member and the expansion device.

95. The apparatus of claim 93, wherein the actuator comprises a plurality of pistons positioned within corresponding piston chambers.

96. The apparatus of claim 84, wherein at least one of the first second expansion devices comprise:
a support member; and
a plurality of movable expansion elements coupled to the support member.

97. The apparatus of claim 96, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

98. The apparatus of claim 97, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

99. The apparatus of claim 98, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

100. The apparatus of claim 98, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

101. The apparatus of claim 84, wherein at least one of the first and second expansion devices comprise a plurality of expansion devices.

102. The apparatus of claim 101, wherein at least one of the first and second expansion device comprise an adjustable expansion device.

103. The apparatus of claim 102, wherein the adjustable expansion device comprises:
a support member; and
a plurality of movable expansion elements coupled to the support member.

104. The apparatus of claim 103, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;
wherein in the first position, the expansion elements do not engage the tubular member; and
wherein in the second position, the expansion elements engage the tubular member.

105. The apparatus of claim 104, wherein the expansion elements comprise:
a first set of expansion elements; and
a second set of expansion elements;
wherein the first set of expansion elements are interleaved with the second set of expansion elements.

106. The apparatus of claim 105, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

107. The apparatus of claim 105, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

108. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
a support member;
a gripping device for gripping the tubular member coupled to the support member;
a sealing device for sealing an interface with the tubular member coupled to the support member;
a locking device for locking the position of the tubular member relative to the support member;
a first adjustable expansion device for radially expanding and plastically deforming the tubular member coupled to the support member;
a second adjustable expansion device for radially expanding and plastically deforming the tubular member coupled to the support member;
a packer coupled to the support member; and
an actuator for displacing one or more of the sealing assembly, first and second adjustable expansion devices, and packer relative to the support member.

109. The apparatus of claim 108, wherein the locking device comprises:
a pressure sensor for controllably unlocking the locking device from engagement with the tubular member when the operating pressure within the apparatus exceeds a predetermined amount.

110. The apparatus of claim 108, wherein the locking device comprises:
a position sensor for controllably unlocking the locking device from engagement with the tubular member when the position of a portion of the apparatus exceeds a predetermined amount.

111. The apparatus of claim 108, wherein the gripping device comprises a plurality of movable gripping elements.

112. The apparatus of claim 111, wherein the gripping elements are moveable in a radial direction relative to the support member.

113. The apparatus of claim 108, wherein the sealing device seals an annulus defines between the support member and the tubular member.

114. The apparatus of claim 108, wherein the actuator comprises means for transferring torsional loads between the support member and the expansion device.

115. The apparatus of claim 108, wherein the actuator comprises a plurality of pistons positioned within corresponding piston chambers.

116. The apparatus of claim 108, wherein at least one of the adjustable expansion devices comprise:
a support member; and
a plurality of movable expansion elements coupled to the support member.

117. The apparatus of claim 116, further comprising:
an actuator coupled to the support member for moving the expansion elements between a first position and a second position;

wherein in the first position, the expansion elements do not engage the tubular member; and

wherein in the second position, the expansion elements engage the tubular member.

118. The apparatus of claim 117, wherein the expansion elements comprise:

a first set of expansion elements; and

a second set of expansion elements;

wherein the first set of expansion elements are interleaved with the second set of expansion elements.

119. The apparatus of claim 118, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

120. The apparatus of claim 118, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

121. The apparatus of claim 108, wherein at least one of the adjustable expansion devices comprise a plurality of expansion devices.

122. The apparatus of claim 121, wherein at least one of the adjustable expansion devices comprise:

a support member; and

a plurality of movable expansion elements coupled to the support member.

123. The apparatus of claim 122, further comprising:

an actuator coupled to the support member for moving the expansion elements between a first position and a second position;

wherein in the first position, the expansion elements do not engage the tubular member; and

wherein in the second position, the expansion elements engage the tubular member.

124. The apparatus of claim 123, wherein the expansion elements comprise:

a first set of expansion elements; and

a second set of expansion elements;

wherein the first set of expansion elements are interleaved with the second set of expansion elements.

125. The apparatus of claim 124, wherein in the first position, the first set of expansion elements are not axially aligned with the second set of expansion elements.

126. The apparatus of claim 124, wherein in the second position, the first set of expansion elements are axially aligned with the second set of expansion elements.

127. An actuator, comprising:
a tubular housing;
a tubular piston rod movably coupled to and at least partially positioned within the housing;
a plurality of annular piston chambers defined by the tubular housing and the tubular piston rod; and
a plurality of tubular pistons coupled to the tubular piston rod, each tubular piston movably positioned within a corresponding annular piston chamber.

128. The actuator of claim 127, further comprising means for transmitting torsional loads between the tubular housing and the tubular piston rod.

129. A method of radially expanding and plastically deforming an expandable tubular member within a borehole having a preexisting wellbore casing, comprising:
positioning the tubular member within the borehole in overlapping relation to the wellbore casing;
radially expanding and plastically deforming a portion of the tubular member to form a bell section; and
radially expanding and plastically deforming a portion of the tubular member above the bell section comprising a portion of the tubular member that overlaps with the wellbore casing;
wherein the inside diameter of the bell section is greater than the inside diameter of the radially expanded and plastically deformed portion of the tubular member above the bell section.

130. The method of claim 129, wherein radially expanding and plastically deforming a

portion of the tubular member to form a bell section comprises:

positioning an adjustable expansion device within the expandable tubular member;

supporting the expandable tubular member and the adjustable expansion device within the borehole;

lowering the adjustable expansion device out of the expandable tubular member;

increasing the outside dimension of the adjustable expansion device; and

displacing the adjustable expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member, wherein n is greater than or equal to 1.

131. A method for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion device within the borehole;

increasing the size of the adjustable expansion device; and

displacing the adjustable expansion device upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

132. The method of claim 131, further comprising:

reducing the size of the adjustable expansion device after the portion of the expandable tubular member has been radially expanded and plastically deformed.

133. The method of claim 132, further comprising:

fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion device.

134. The method of claim 133, further comprising:

permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

135. The method of claim 134, further comprising:
injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

136. The method of claim 134, further comprising:
increasing the size of the adjustable expansion device after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

137. The method of claim 136, further comprising:
displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

138. The method of claim 137, further comprising:
if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then
not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

139. A method for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing, comprising:
supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion device within the borehole;
increasing the size of the adjustable expansion device;
displacing the adjustable expansion device upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically

deform a portion of the expandable tubular member; and

displacing the adjustable expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

140. The method of claim 139, further comprising:

reducing the size of the adjustable expansion device after the portion of the expandable tubular member has been radially expanded and plastically deformed.

141. The method of claim 140, further comprising:

fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion device.

142. The method of claim 141, further comprising:

permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

143. The method of claim 142, further comprising:

injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

144. The method of claim 142, further comprising:

increasing the size of the adjustable expansion device after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

145. The method of claim 144, further comprising:

displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member.

146. The method of claim 145, further comprising:

not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and

displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

147. A method of radially expanding and plastically deforming a tubular member, comprising:

positioning the tubular member within a preexisting structure;

radially expanding and plastically deforming a lower portion of the tubular member to form a bell section; and

radially expanding and plastically deforming a portion of the tubular member above the bell section.

148. The method of claim 147, wherein positioning the tubular member within a preexisting structure comprises:

locking the tubular member to an expansion device.

149. The method of claim 148, wherein positioning the tubular member within a preexisting structure comprises:

unlocking the tubular member from an expansion device if the operating pressure within the preexisting structure exceeds a predetermined amount.

150. The method of claim 148, wherein positioning the tubular member within a preexisting structure comprises:

unlocking the tubular member from an expansion device if the position of an actuator coupled to the tubular member exceeds a predetermined amount.

151. The method of claim 147, wherein radially expanding and plastically deforming a lower portion of the tubular member to form a bell section comprises:

lowering an expansion device out of an end of the tubular member; and

pulling the expansion device through the end of the tubular member.

152. The method of claim 151, wherein lowering an expansion device out of an end of the tubular member comprises:

lowering the expansion device out of the end of the tubular member; and

adjusting the size of the expansion device.

153. The method of claim 152, wherein the expansion device is adjustable to a plurality of sizes.

154. The method of claim 152, wherein the expansion device comprises a plurality of adjustable expansion devices.

155. The method of claim 154, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

156. The method of claim 151, wherein pulling the expansion device through the end of the tubular member comprises:

gripping the tubular member; and

pulling an expansion device through an end of the tubular member.

157. The method of claim 156, wherein gripping the tubular member comprises:

permitting axial displacement of the tubular member in a first direction; and

not permitting axial displacement of the tubular member in a second direction.

158. The method of claim 156, wherein pulling the expansion device through the end of the tubular member comprises:

pulling the expansion device through the end of the tubular member using an

actuator.

159. The method of claim 142, wherein radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

lowering an expansion device out of an end of the tubular member; and

pulling the expansion device through the end of the tubular member.

160. The method of claim 159, wherein lowering an expansion device out of an end of the tubular member comprises:

lowering the expansion device out of the end of the tubular member; and

adjusting the size of the expansion device.

161. The method of claim 160, wherein the expansion device is adjustable to a plurality of sizes.

162. The method of claim 160, wherein the expansion device comprises a plurality of adjustable expansion devices.

163. The method of claim 162, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

164. The method of claim 159, wherein pulling the expansion device through the end of the tubular member comprises:

gripping the tubular member; and

pulling an expansion device through an end of the tubular member.

165. The method of claim 164, wherein gripping the tubular member comprises:

permitting axial displacement of the tubular member in a first direction; and

not permitting axial displacement of the tubular member in a second direction.

166. The method of claim 164, wherein pulling the expansion device through the end of the tubular member comprises:

pulling the expansion device through the end of the tubular member using an actuator.

167. The method of claim 159, wherein pulling the expansion device through the end of the tubular member comprises:

pulling the expansion device through the end of the tubular member using fluid pressure.

168. The method of claim 167, wherein pulling the expansion device through the end of the tubular member using fluid pressure comprises:

pressurizing an annulus within the tubular member above the expansion device.

169. The method of claim 147, wherein radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

fluidicly sealing an end of the tubular member; and

pulling the expansion device through the tubular member.

170. The method of claim 169, wherein the expansion device is adjustable.

171. The method of claim 170, wherein the expansion device is adjustable to a plurality of sizes.

172. The method of claim 169, wherein the expansion device comprises a plurality of adjustable expansion devices.

173. The method of claim 172, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

174. The method of claim 169, wherein pulling the expansion device through the end of the tubular member comprises:

gripping the tubular member; and

pulling an expansion device through an end of the tubular member.

175. The method of claim 174, wherein pulling the expansion device through the end of the tubular member comprises:

pulling the expansion device through the end of the tubular member using an

actuator.

176. The method of claim 169, wherein pulling the expansion device through the end of the tubular member comprises:

pulling the expansion device through the end of the tubular member using fluid pressure.

177. The method of claim 176, wherein pulling the expansion device through the end of the tubular member using fluid pressure comprises:

pressurizing an annulus within the tubular member above the expansion device.

178. The method of claim 147, wherein radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

overlapping the portion of the tubular member above the bell section with an end of a preexisting tubular member; and

pulling an expansion device through the overlapping portions of the tubular member and the preexisting tubular member.

179. The method of claim 178, wherein the expansion device is adjustable.

180. The method of claim 179, wherein the expansion device is adjustable to a plurality of sizes.

181. The method of claim 178, wherein the expansion device comprises a plurality of adjustable expansion devices.

182. The method of claim 181, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

183. The method of claim 178, wherein pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

gripping the tubular member; and

pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member.

184. The method of claim 183, wherein pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using an actuator.

185. The method of claim 178, wherein pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using fluid pressure.

186. The method of claim 185, wherein pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using fluid pressure comprises:

pressurizing an annulus within the tubular member above the expansion device.

187. The method of claim 147, further comprising:

injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the preexisting structure.

188. A method of injecting a hardenable fluidic sealing material into an annulus between a tubular member and a preexisting structure, comprising:

positioning the tubular member into the preexisting structure;

sealing off an end of the tubular member;

operating a valve within the end of the tubular member; and

injecting a hardenable fluidic sealing material through the valve into the annulus between the tubular member and the preexisting structure.

189. A method of engaging a tubular member, comprising:

positioning a plurality of elements within the tubular member; and

bringing the elements into engagement with the tubular member.

190. The method of claim 189, wherein the elements comprise:

a first group of elements; and

a second group of elements;

wherein the first group of elements are interleaved with the second group of elements.

191. The method of claim 189, wherein bringing the elements into engagement with the tubular member comprises:

bringing the elements into axial alignment.

192. The method of claim 189, wherein bringing the elements into engagement with the tubular member further comprises:

pivoting the elements.

193. The method of claim 189, wherein bringing the elements into engagement with the tubular member further comprises:

translating the elements.

194. The method of claim 189, wherein bringing the elements into engagement with the tubular member further comprises:

pivoting the elements; and

translating the elements.

195. The method of claim 189, wherein bringing the elements into engagement with the tubular member comprises:

rotating the elements about a common axis.

196. The method of claim 189, wherein bringing the elements into engagement with the tubular member comprises:

pivoting the elements about corresponding axes;

translating the elements; and

rotating the elements about a common axis.

197. The method of claim 189, further comprising:

preventing the elements from coming into engagement with the tubular member if the inside diameter of the tubular member is less than a predetermined value.

198. The method of claim 197, wherein preventing the elements from coming into engagement with the tubular member if the inside diameter of the tubular member is less than a predetermined value comprises:

sensing the inside diameter of the tubular member.

199. A locking device for locking a tubular member to a support member, comprising:

a radially movable locking device coupled to the support member for engaging an interior surface of the tubular member.

200. The device of claim 199, further comprising:

a pressure sensor for controllably unlocking the locking device from engagement with the tubular member when an operating pressure exceeds a predetermined amount.

201. The device of claim 199, further comprising:

a position sensor for controllably unlocking the locking device from engagement with the tubular member when a position exceeds a predetermined amount.

202. A method of locking a tubular member to a support member, comprising:

locking a locking element in a position that engages an interior surface of the tubular member.

203. The method of claim 202, further comprising:

controllably unlocking the locking element from engagement with the tubular member when an operating pressure exceeds a predetermined amount.

204. The method of claim 202, further comprising:

controllably unlocking the locking element from engagement with the tubular member when a position exceeds a predetermined amount.

205. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning an adjustable expansion mandrel within the expandable tubular

member;

means for supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

means for lowering the adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel; and

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member.

206. A system for forming a mono diameter wellbore casing, comprising:

positioning an adjustable expansion mandrel within a first expandable tubular member;

means for supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;

means for lowering the adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;

means for positioning the adjustable expansion mandrel within a second expandable tubular member;

means for supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;

means for lowering the adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel; and

means for displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

207. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning an adjustable expansion mandrel within the expandable tubular member;

means for supporting the expandable tubular member and the adjustable expansion mandrel within the borehole;

means for lowering the adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole; and

means for pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

208. A system for forming a mono diameter wellbore casing, comprising:

means for positioning an adjustable expansion mandrel within a first expandable tubular member;

means for supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole;

means for lowering the adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole;

means for pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole;

means for positioning the adjustable expansion mandrel within a second expandable tubular member;

means for supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member;

means for lowering the adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole; and

means for pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

209. A system for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

means for positioning an adjustable expansion mandrel within the expandable tubular member;

means for coupling a drilling member to an end of the expandable tubular member;

means for drilling the borehole using the drilling member;

means for positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;

means for lowering the adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel; and

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole.

210. A system for forming a mono diameter wellbore casing within a borehole, comprising:

means for positioning an adjustable expansion mandrel within a first expandable

tubular member;

means for coupling a drilling member to an end of the first expandable tubular member;

means for drilling a first section of the borehole using the drilling member;

means for supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;

means for lowering the adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;

means for positioning the adjustable expansion mandrel within a second expandable tubular member;

means for coupling the drilling member to an end of the second expandable tubular member;

means for drilling a second section of the borehole using the drilling member;

means for supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;

means for lowering the adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel; and

means for displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole.

211. A system for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole, comprising:

means for positioning an adjustable expansion mandrel within the expandable tubular

member;

means for coupling a drilling member to an end of the expandable tubular member;

means for drilling the borehole using the drilling member;

means for positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole;

means for lowering the adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the drilled borehole; and

means for pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

212. A system for forming a mono diameter wellbore casing within a borehole, comprising:

means for positioning an adjustable expansion mandrel within a first expandable tubular member;

means for coupling a drilling member to an end of the first expandable tubular member;

means for drilling a first section of the borehole using the drilling member;

means for supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole;

means for lowering the adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the drilled first section of the borehole;

means for pressuring an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole;

means for positioning the adjustable expansion mandrel within a second expandable tubular member;

means for coupling the drilling member to an end of the second expandable tubular member;

means for drilling a second section of the borehole using the drilling member;

means for supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole;

means for lowering the adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the drilled second section of the borehole; and

means for pressuring an interior portion of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the drilled second section of the borehole.

213. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning first and second adjustable expansion mandrels within the expandable tubular member;

means for supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

means for lowering the first adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

means for displacing the first adjustable expansion mandrel and the second

adjustable expansion mandrel downwardly relative to the expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

means for displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

214. A system for forming a mono diameter wellbore casing, comprising:

means for positioning first and second adjustable expansion mandrels within a first expandable tubular member;

means for supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

means for lowering the first adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

means for displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

means for displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member;

means for positioning first and second adjustable expansion mandrels within a second expandable tubular member;

means for supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

means for lowering the first adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

means for displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel; and

means for displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

215. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for positioning first and second adjustable expansion mandrels within the expandable tubular member;

means for supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole;

means for lowering the first adjustable expansion mandrel out of the expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion

mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member;

means for pressurizing an interior region of the expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the expandable tubular member by the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

means for displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member; and

means for pressurizing an interior region of the expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the expandable tubular member above the lower portion of the expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

216. A system for forming a mono diameter wellbore casing, comprising:

means for positioning first and second adjustable expansion mandrels within a first expandable tubular member;

means for supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole;

means for lowering the first adjustable expansion mandrel out of the first expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member;

means for pressurizing an interior region of the first expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the first expandable tubular member by the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

means for displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform portions of the first expandable tubular member above the lower portion of the expandable tubular member;

means for pressurizing an interior region of the first expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the first expandable tubular member above the lower portion of the first expandable tubular member by the second adjustable expansion mandrel;

means for positioning first and second adjustable expansion mandrels within a second expandable tubular member;

means for supporting the first expandable tubular member and the first and second adjustable expansion mandrels within the borehole in overlapping relation to the first expandable tubular member;

means for lowering the first adjustable expansion mandrel out of the second expandable tubular member;

means for increasing the outside dimension of the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform a lower portion of the second expandable tubular member;

means for pressurizing an interior region of the second expandable tubular member above the first adjustable expansion mandrel during the radial expansion of the lower portion of the second expandable tubular member by the first adjustable expansion mandrel;

means for displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the second expandable tubular member;

means for decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel;

means for displacing the second adjustable expansion mandrel upwardly relative to the second expandable tubular member to radially expand and plastically deform portions of the second expandable tubular member above the lower portion of the second expandable tubular member; and

means for pressurizing an interior region of the second expandable tubular member above the second adjustable expansion mandrel during the radial expansion of the portions of the second expandable tubular member above the lower portion of the second expandable tubular member by the second adjustable expansion mandrel;

wherein the outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

217. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;

means for increasing the size of the adjustable expansion mandrel; and

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

218. The system of claim 217, further comprising:

means for reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed.

219. The system of claim 218, further comprising:
means for fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

220. The system of claim 219, further comprising:
means for permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

221. The system of claim 220, further comprising:
means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

222. The system of claim 220, further comprising:
means for increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

223. The system of claim 222, further comprising:
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

224. The system of claim 223, further comprising:
if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then
means for not permitting the position of the expandable tubular member to

float relative to the position of the hydraulic actuator; and

means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

225. A system for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing, comprising:

means for supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion mandrel within the borehole;

means for increasing the size of the adjustable expansion mandrel;

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member; and

means for displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

226. The system of claim 225, further comprising:

means for reducing the size of the adjustable expansion mandrel after the portion of the expandable tubular member has been radially expanded and plastically deformed.

227. The system of claim 226, further comprising:

means for fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion mandrel.

228. The system of claim 227, further comprising:
means for permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

229. The system of claim 228, further comprising:
means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

230. The system of claim 228, further comprising:
means for increasing the size of the adjustable expansion mandrel after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

231. The system of claim 230, further comprising:
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member.

232. The system of claim 231, further comprising:
means for not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

233. A system of radially expanding and plastically deforming an expandable tubular member within a borehole having a preexisting wellbore casing, comprising:

means for positioning the tubular member within the borehole in overlapping relation to the wellbore casing;

means for radially expanding and plastically deforming a portion of the tubular member to form a bell section; and

means for radially expanding and plastically deforming a portion of the tubular member above the bell section comprising a portion of the tubular member that overlaps with the wellbore casing;

wherein the inside diameter of the bell section is greater than the inside diameter of the radially expanded and plastically deformed portion of the tubular member above the bell section.

234. The system of claim 233, wherein radially expanding and plastically deforming a portion of the tubular member to form a bell section comprises:

means for positioning an adjustable expansion device within the expandable tubular member;

means for supporting the expandable tubular member and the adjustable expansion device within the borehole;

means for lowering the adjustable expansion device out of the expandable tubular member;

means for increasing the outside dimension of the adjustable expansion device; and

means for displacing the adjustable expansion device upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member, wherein n is greater than or equal to 1.

235. A system for radially expanding and plastically deforming an expandable tubular member within a borehole, comprising:

means for supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion device within the borehole;

means for increasing the size of the adjustable expansion device; and

means for displacing the adjustable expansion device upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member.

236. The system of claim 235, further comprising:
means for reducing the size of the adjustable expansion device after the portion of the expandable tubular member has been radially expanded and plastically deformed.

237. The system of claim 236, further comprising:
means for fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion device.

238. The system of claim 237, further comprising:
means for permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

239. The system of claim 238, further comprising:
means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and a preexisting structure after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

240. The system of claim 238, further comprising:
means for increasing the size of the adjustable expansion device after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

241. The system of claim 240, further comprising:
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

242. The system of claim 241, further comprising:
if the end of the other portion of the expandable tubular member overlaps with a preexisting structure, then

means for not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and

means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the other portion of the expandable tubular member that overlaps with the preexisting structure.

243. A system for forming a mono diameter wellbore casing within a borehole that includes a preexisting wellbore casing, comprising:

means for supporting the expandable tubular member, an hydraulic actuator, and an adjustable expansion device within the borehole;

means for increasing the size of the adjustable expansion device;

means for displacing the adjustable expansion device upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform a portion of the expandable tubular member; and

means for displacing the adjustable expansion device upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member and a portion of the preexisting wellbore casing that overlaps with an end of the remaining portion of the expandable tubular member.

244. The system of claim 243, further comprising:

means for reducing the size of the adjustable expansion device after the portion of the expandable tubular member has been radially expanded and plastically deformed.

245. The system of claim 244, further comprising:

means for fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member after reducing the size of the adjustable expansion device.

246. The system of claim 245, further comprising:
means for permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator after fluidicly sealing the radially expanded and plastically deformed end of the expandable tubular member.

247. The system of claim 246, further comprising:
means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

248. The system of claim 246, further comprising:
means for increasing the size of the adjustable expansion device after permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

249. The system of claim 248, further comprising:
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member to radially expand and plastically deform the remaining portion of the expandable tubular member.

250. The system of claim 249, further comprising:
means for not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator; and
means for displacing the adjustable expansion cone upwardly relative to the expandable tubular member using the hydraulic actuator to radially expand and plastically deform the end of the remaining portion of the expandable tubular member that overlaps with the preexisting wellbore casing after not permitting the position of the expandable tubular member to float relative to the position of the hydraulic actuator.

251. A system for radially expanding and plastically deforming a tubular member, comprising:
means for positioning the tubular member within a preexisting structure;

means for radially expanding and plastically deforming a lower portion of the tubular member to form a bell section; and

means for radially expanding and plastically deforming a portion of the tubular member above the bell section.

252. The system of claim 251, wherein positioning the tubular member within a preexisting structure comprises:

means for locking the tubular member to an expansion device.

253. The system of claim 252, wherein positioning the tubular member within a preexisting structure comprises:

means for unlocking the tubular member from an expansion device if the operating pressure within the preexisting structure exceeds a predetermined amount.

254. The system of claim 252, wherein positioning the tubular member within a preexisting structure comprises:

means for unlocking the tubular member from an expansion device if the position of an actuator coupled to the tubular member exceeds a predetermined amount.

255. The system of claim 251, wherein radially expanding and plastically deforming a lower portion of the tubular member to form a bell section comprises:

means for lowering an expansion device out of an end of the tubular member; and

means for pulling the expansion device through the end of the tubular member.

256. The system of claim 255, wherein lowering an expansion device out of an end of the tubular member comprises:

means for lowering the expansion device out of the end of the tubular member; and

means for adjusting the size of the expansion device.

257. The system of claim 256, wherein the expansion device is adjustable to a plurality of sizes.

258. The system of claim 256, wherein the expansion device comprises a plurality of adjustable expansion devices.

259. The system of claim 258, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

260. The system of claim 255, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for gripping the tubular member; and

means for pulling an expansion device through an end of the tubular member.

261. The system of claim 260, wherein means for gripping the tubular member comprises:

means for permitting axial displacement of the tubular member in a first direction; and

means for not permitting axial displacement of the tubular member in a second direction.

262. The system of claim 260, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for pulling the expansion device through the end of the tubular member using an actuator.

263. The system of claim 246, wherein means for radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

means for lowering an expansion device out of an end of the tubular member; and

means for pulling the expansion device through the end of the tubular member.

264. The system of claim 263, wherein means for lowering an expansion device out of an end of the tubular member comprises:

means for lowering the expansion device out of the end of the tubular member; and

means for adjusting the size of the expansion device.

265. The system of claim 264, wherein the expansion device is adjustable to a plurality of sizes.

266. The system of claim 264, wherein the expansion device comprises a plurality of adjustable expansion devices.

267. The system of claim 266, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

268. The system of claim 263, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for gripping the tubular member; and

means for pulling an expansion device through an end of the tubular member.

269. The system of claim 268, wherein means for gripping the tubular member comprises:

means for permitting axial displacement of the tubular member in a first direction; and

means for not permitting axial displacement of the tubular member in a second direction.

270. The system of claim 268, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for pulling the expansion device through the end of the tubular member using an actuator.

271. The system of claim 263, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for pulling the expansion device through the end of the tubular member using fluid pressure.

272. The system of claim 271, wherein means for pulling the expansion device through the end of the tubular member using fluid pressure comprises:

means for pressurizing an annulus within the tubular member above the expansion device.

273. The system of claim 251, wherein means for radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

means for fluidicly sealing an end of the tubular member; and

means for pulling the expansion device through the tubular member.

274. The system of claim 273, wherein the expansion device is adjustable.

275. The system of claim 274, wherein the expansion device is adjustable to a plurality of sizes.

276. The system of claim 273, wherein the expansion device comprises a plurality of adjustable expansion devices.

277. The system of claim 276, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

278. The system of claim 273, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for gripping the tubular member; and

means for pulling an expansion device through an end of the tubular member.

279. The system of claim 278, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for pulling the expansion device through the end of the tubular member using an actuator.

280. The system of claim 273, wherein means for pulling the expansion device through the end of the tubular member comprises:

means for pulling the expansion device through the end of the tubular member using fluid pressure.

281. The system of claim 280, wherein means for pulling the expansion device through the end of the tubular member using fluid pressure comprises:

means for pressurizing an annulus within the tubular member above the expansion device.

282. The system of claim 251, wherein means for radially expanding and plastically deforming a portion of the tubular member above the bell section comprises:

means for overlapping the portion of the tubular member above the bell section with an end of a preexisting tubular member; and

means for pulling an expansion device through the overlapping portions of the tubular member and the preexisting tubular member.

283. The system of claim 282, wherein the expansion device is adjustable.

284. The system of claim 283, wherein the expansion device is adjustable to a plurality of sizes.

285. The system of claim 282, wherein the expansion device comprises a plurality of adjustable expansion devices.

286. The system of claim 285, wherein at least one of the adjustable expansion devices is adjustable to a plurality of sizes.

287. The system of claim 282, wherein means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

means for gripping the tubular member; and

means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member.

288. The system of claim 287, wherein means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using an actuator.

289. The system of claim 282, wherein means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member comprises:

means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using fluid pressure.

290. The system of claim 289, wherein means for pulling the expansion device through the overlapping portions of the tubular member and the preexisting tubular member using fluid pressure comprises:

means for pressurizing an annulus within the tubular member above the expansion device.

291. The system of claim 251, further comprising:

means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the preexisting structure.

292. A system of injecting a hardenable fluidic sealing material into an annulus between a tubular member and a preexisting structure, comprising:

means for positioning the tubular member into the preexisting structure;

means for sealing off an end of the tubular member;

means for operating a valve within the end of the tubular member; and

means for injecting a hardenable fluidic sealing material through the valve into the annulus between the tubular member and the preexisting structure.

293. A system of engaging a tubular member, comprising:

means for positioning a plurality of elements within the tubular member; and

means for bringing the elements into engagement with the tubular member.

294. The system of claim 293, wherein the elements comprise:

a first group of elements; and

a second group of elements;

wherein the first group of elements are interleaved with the second group of elements.

295. The system of claim 293, wherein means for bringing the elements into engagement with the tubular member comprises:

means for bringing the elements into axial alignment.

296. The system of claim 293, wherein means for bringing the elements into engagement with the tubular member further comprises:

means for pivoting the elements.

297. The system of claim 189, wherein means for bringing the elements into engagement with the tubular member further comprises:

means for translating the elements.

298. The system of claim 293, wherein means for bringing the elements into engagement with the tubular member further comprises:

means for pivoting the elements; and

means for translating the elements.

299. The system of claim 293, wherein means for bringing the elements into engagement with the tubular member comprises:

means for rotating the elements about a common axis.

300. The system of claim 293, wherein means for bringing the elements into engagement with the tubular member comprises:

means for pivoting the elements about corresponding axes;

means for translating the elements; and

means for rotating the elements about a common axis.

301. The system of claim 293, further comprising:

means for preventing the elements from coming into engagement with the tubular member if the inside diameter of the tubular member is less than a predetermined value.

302. The system of claim 301, wherein means for preventing the elements from coming into engagement with the tubular member if the inside diameter of the tubular member is less than a predetermined value comprises:

means for sensing the inside diameter of the tubular member.

303. A system of locking a tubular member to a support member, comprising:

locking a locking element in a position that engages an interior surface of the tubular member.

304. The system of claim 303, further comprising:
means for controllably unlocking the locking element from engagement with the tubular member when an operating pressure exceeds a predetermined amount.

305. The system of claim 303, further comprising:
means for controllably unlocking the locking element from engagement with the tubular member when a position exceeds a predetermined amount.

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INT CL^7 **E21B**
Other: **Online: WPI, EPODOC, PAJ**
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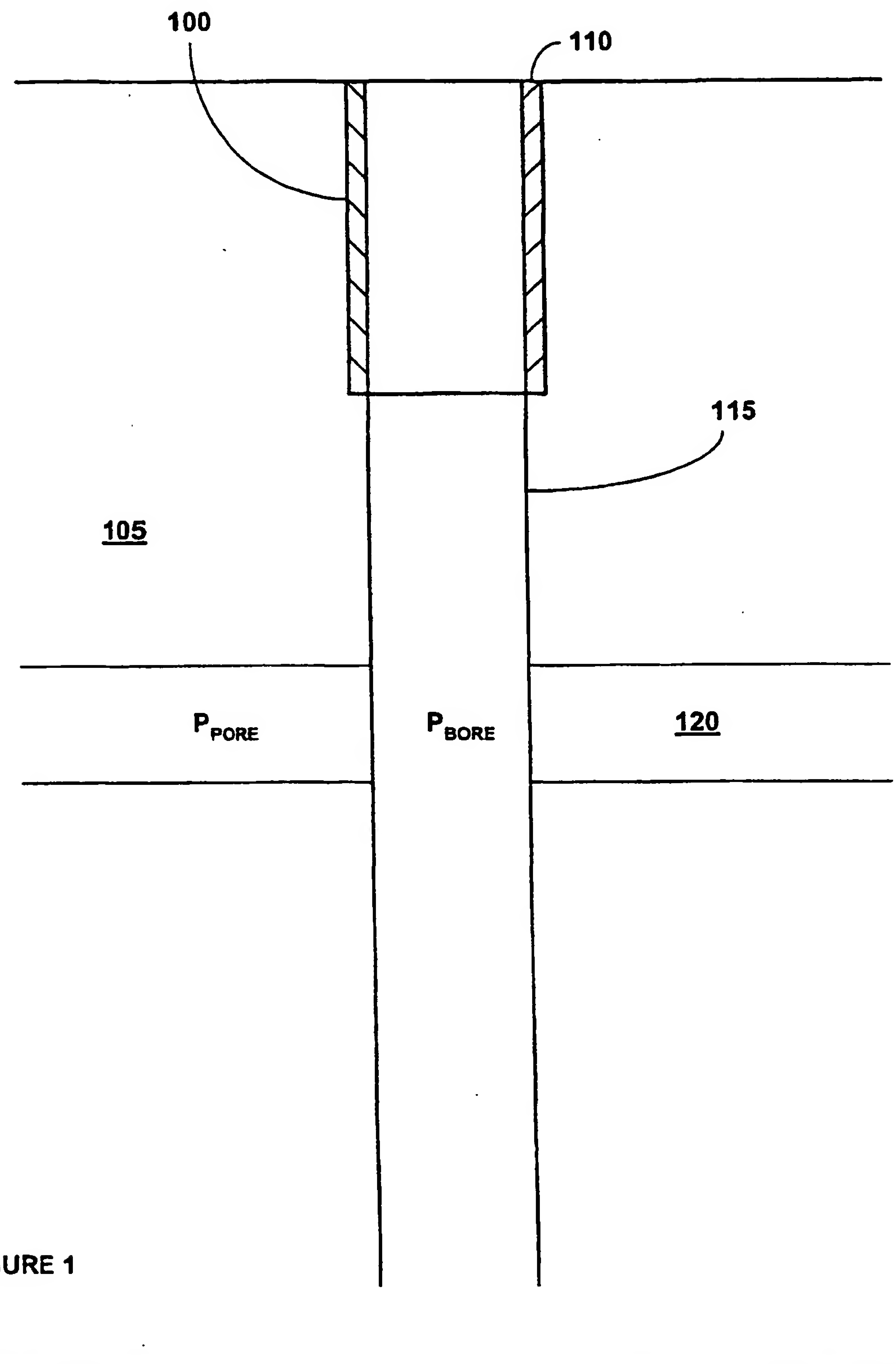

FIGURE 1

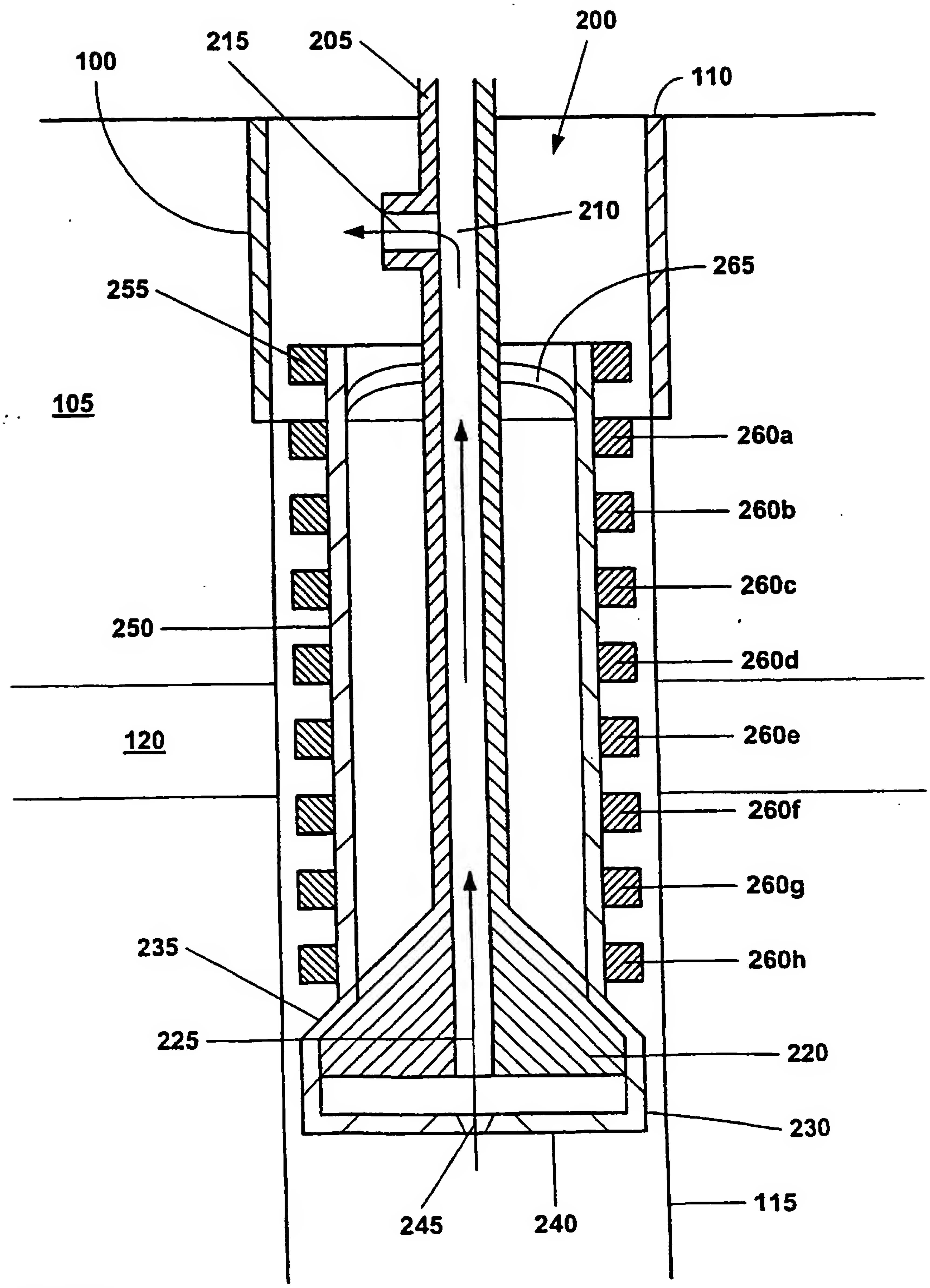
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FIGURE 2

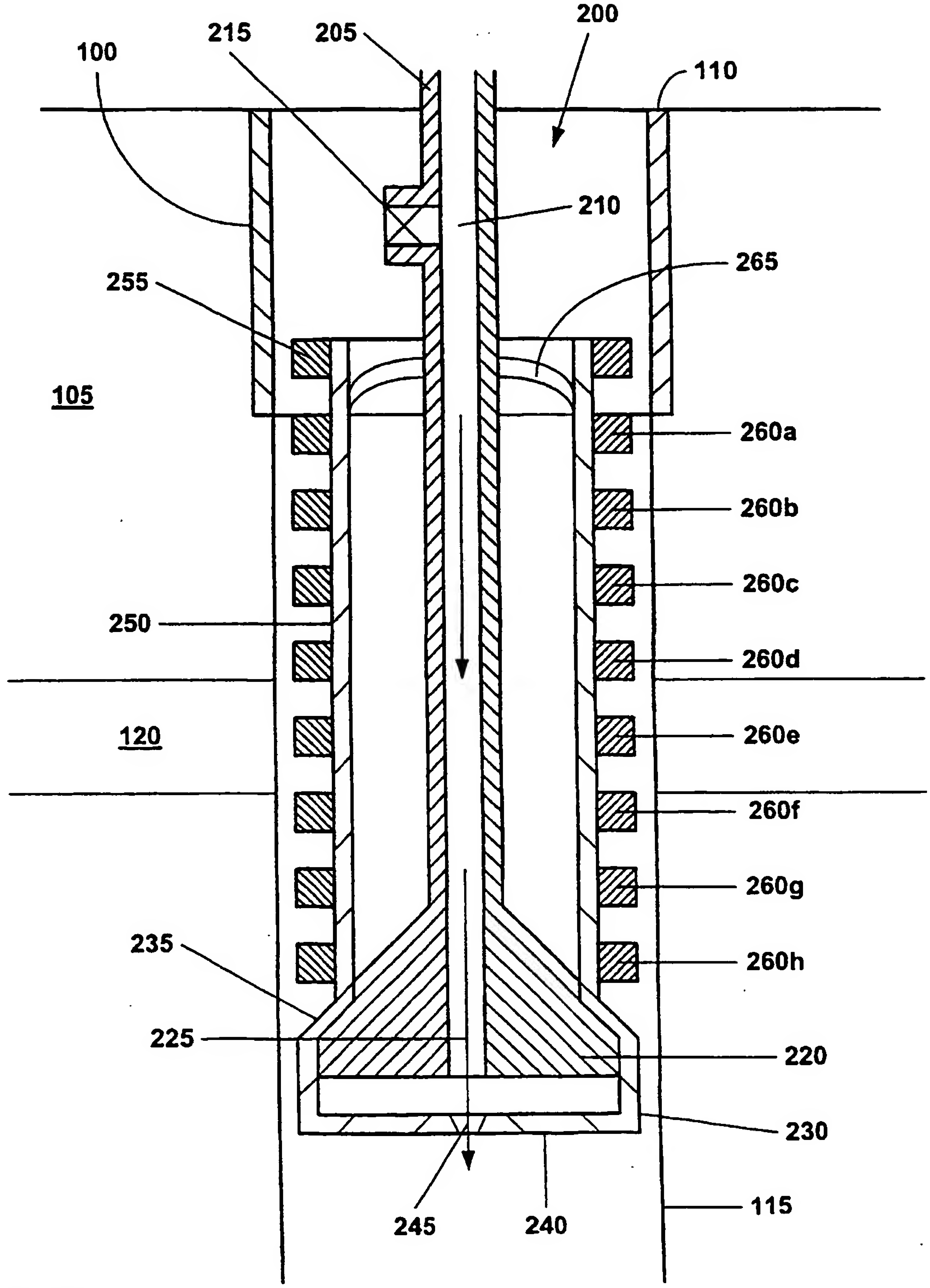
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FIGURE 3

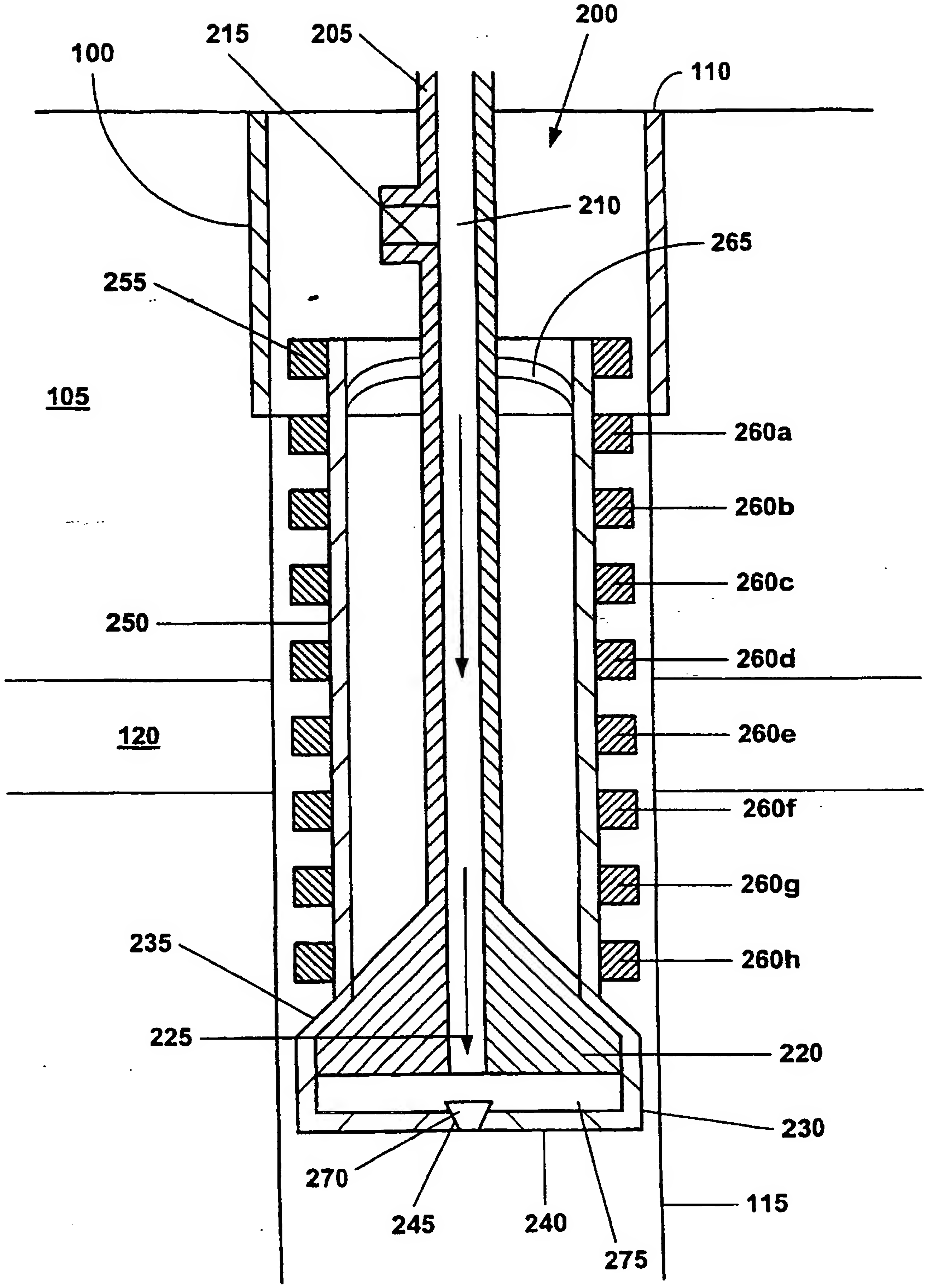

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FIGURE 4

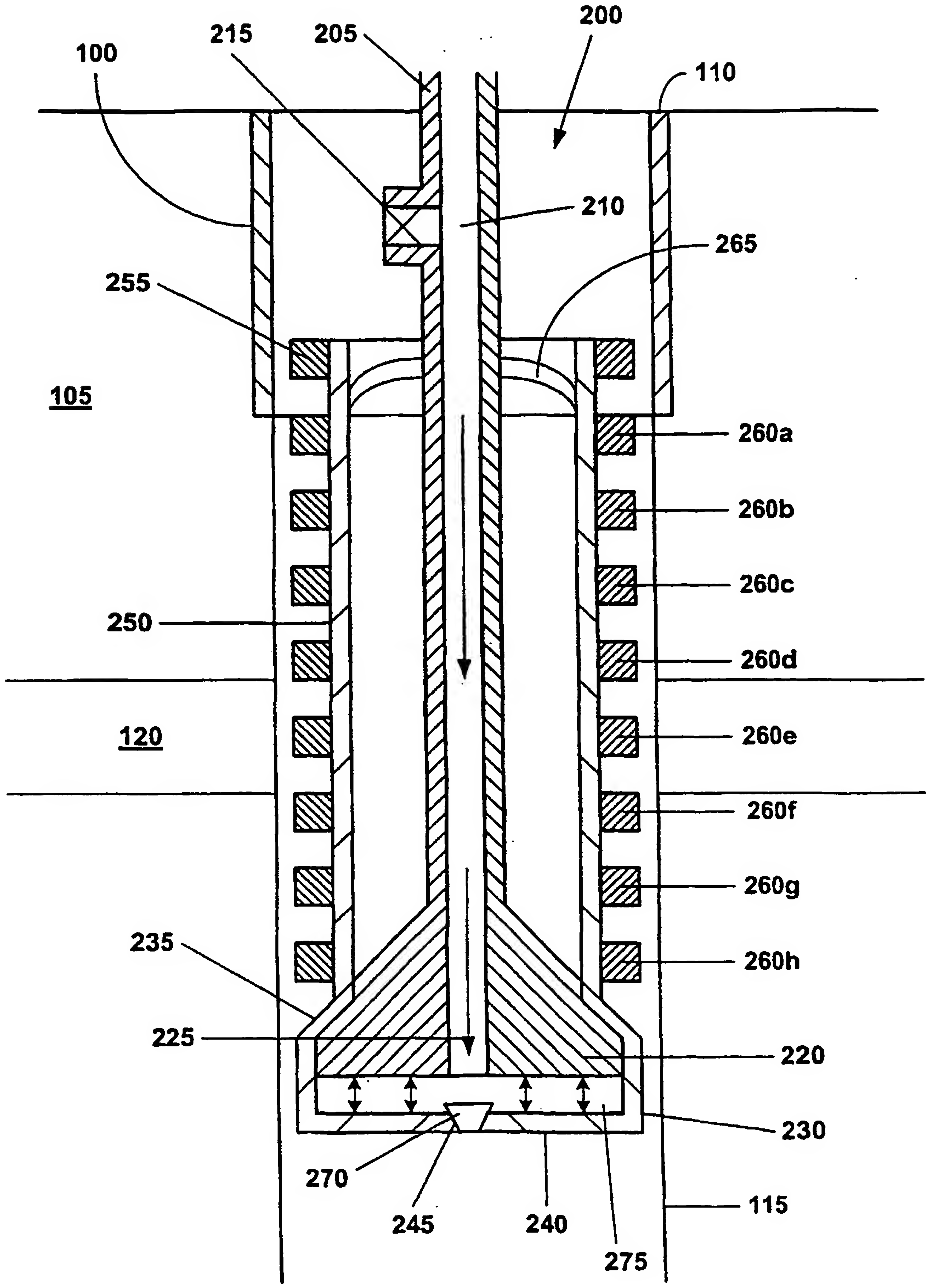

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FIGURE 5

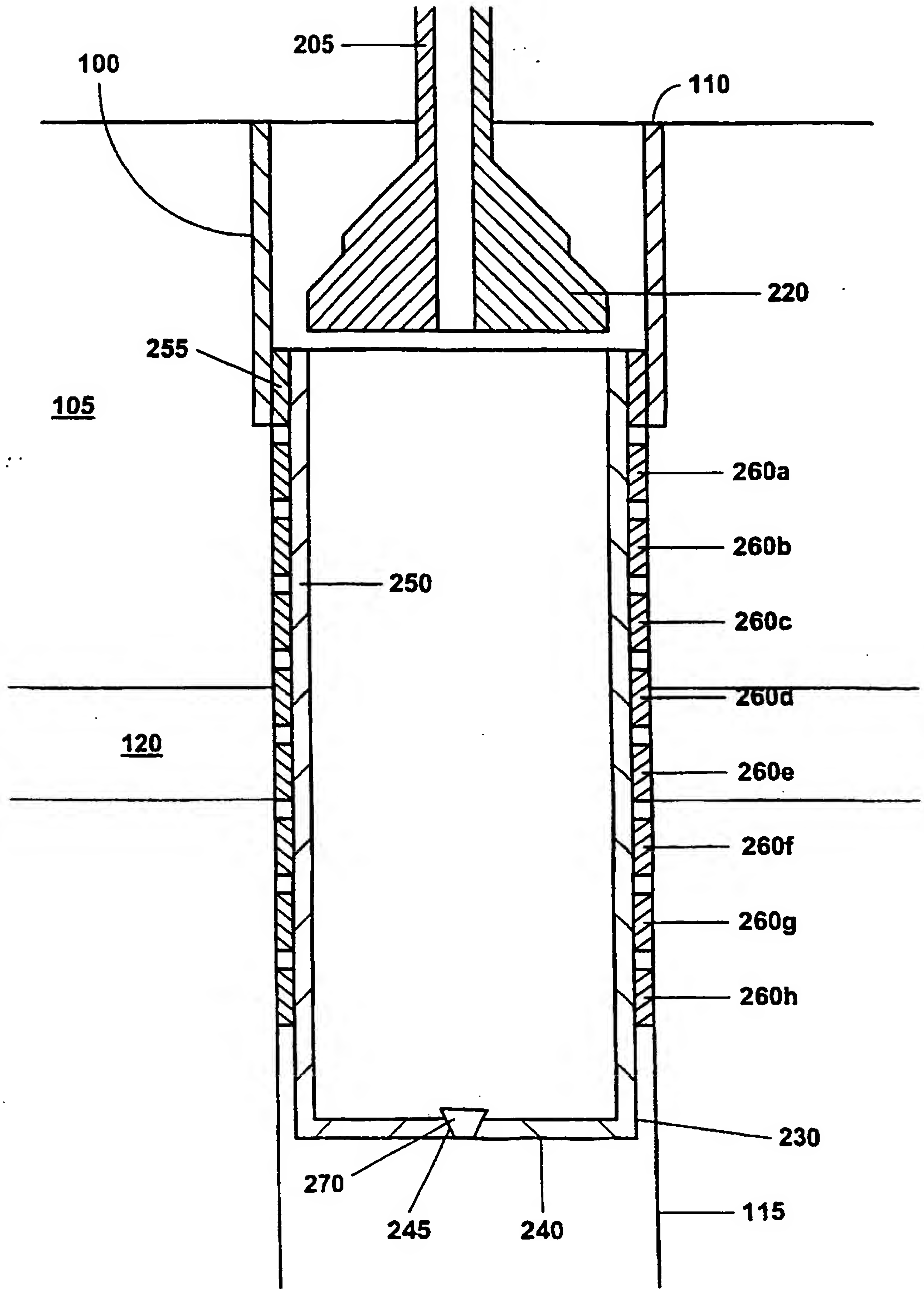
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FIGURE 6

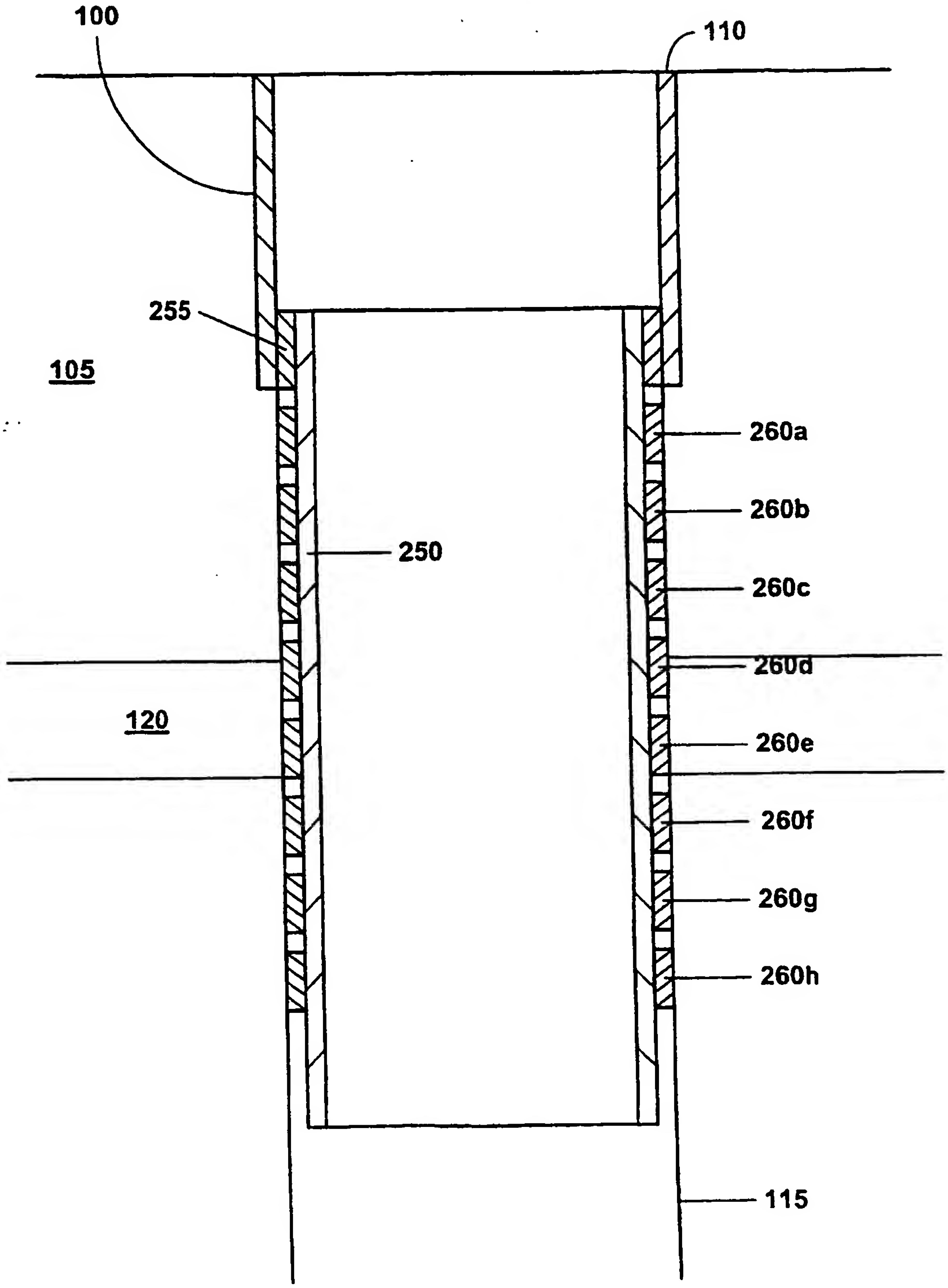

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FIGURE 7

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COUPLING AN EXPANDABLE LINER TO A WELLBORE CASING

This invention relates to coupling an expandable liner to a wellbore casing.

Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores and wellheads.

Summary of the Invention

According to a first aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion cone within the wellbore;

overlapping a portion of the solid tubular liner with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone proximate the porous subterranean zone.

According to a second aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion cone within the wellbore;

overlapping a portion of the solid tubular liner with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

According to a third aspect of the present invention there is provided in an An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion cone coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion cone launcher movably coupled to and mating with the expansion cone;

a tubular liner coupled to an end of the tubular expansion cone launcher; and

a shoe coupled to another end of the tubular expansion cone launcher including a valveable passage; and

means for during a radial expansion of a portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore including a wellbore casing and an open hole section that traverses a porous subterranean layer.

FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of an apparatus for casing the open hole section of the wellbore of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a fluidic material into the apparatus of FIG. 2.

FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a plug into the exhaust passage of the shoe of the apparatus of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the pressurization of the interior portion of the apparatus below the expansion cone of FIG. 4.

FIG. 6 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the tubular member of the apparatus of FIG. 5.

FIG. 7 is a fragmentary cross-sectional view illustrating the removal of the shoe from the apparatus of FIG. 6.

Detailed Description of the Illustrative Embodiments

An apparatus and method for casing an open hole section of a wellbore within a subterranean formation is provided. The apparatus and method provides a system for casing an open hole section of a wellbore within a subterranean formation in which a tubular member having a plurality of radially oriented standoffs is radially expanded into contact with the preexisting wellbore casing and the open hole section. The standoffs provided on the exterior surface of the tubular member preferably position the tubular member away from the interior walls of the open hole section during the radial expansion process. In this manner, the tubular member does not adhere to underpressurized sections of the open hole section of the wellbore. In this manner, the process of radial expansion is more reliable.

Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 and an open hole section 115 that traverses an porous region 120. When the operating pressure within the wellbore P_{BORE} is greater than the operating pressure within the porous region P_{PORE}, fluidic materials will flow from the wellbore 100 into the porous region 120. As a result of the flow of fluidic materials from the wellbore 100 into the porous region 120, downhole equipment will tend to adhere to, or at least be drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. This can have serious and adverse consequences when radially expanding a tubular member in such an operating environment.

Referring to Fig. 2, an apparatus 200 for forming a wellbore casing in the open hole section of the wellbore 100 may then be positioned within the wellbore in an overlapping relationship with the lower portion of the preexisting wellbore casing 110.

The apparatus 200 includes a tubular support member 205 having a longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidicly coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250 extends from the expansion cone launcher 230 that includes a sealing member 255 and a plurality of standoffs 260a-260h affixed to the exterior surface of the expandable tubular member. In a preferred embodiment, the standoffs 260 are fabricated from a resilient material. A sealing cup 265 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent 6,328,113 issued December 11, 2001, and filed as application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent 6,497,289, issued December 24, 2002, and filed as application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application

serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent 6,575,240 issued June 10, 2003, and filed as application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent 6,604,763, issued August 12, 2003, and filed as application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent 6,557,640, issued May 6, 2003, and filed as application serial number 09/588,946, attorney docket number 25791.17.02, filed on June 7, 2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent 6,568,471 issued May 27, 2003, and filed as application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number 60/212,359, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional

patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999.

As illustrated in Fig. 2, during placement of the apparatus 200 within the wellbore 100, fluidic materials displaced by the apparatus 200 are conveyed through the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore 100 are minimized. Furthermore, as illustrated in Fig. 2, the apparatus 200 is preferably initially positioned with upper portion of the tubular member 250 in opposing relation to the lower portion of the preexisting wellbore casing 110. In this manner, the upper portion of the tubular member 250 may be radially expanded into contact with the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the placement of the apparatus 200 within the wellbore 100, the standoffs 260a-260h prevent the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is approximately centered within the wellbore 100.

As illustrated in Fig. 3, the transverse passage 215 may then be closed and fluidic materials injected into the apparatus 200 through the longitudinal passage 210. In this manner, any blockages within any of the passages 210, 225, and 245 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

As illustrated in Fig. 4, a plug 270 or other conventional stop member may then be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 270 may be positioned within the exhaust passage 245. In this manner, the exhaust passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby pressurize a region 275 below the expansion cone 220.

As illustrated in Figs. 5 and 6, continued pressurization of the region 275 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper portion of the radially expanded

tubular member 250 is coupled to the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the radial expansion process, the tubular support member 205 is raised out of the wellbore 100.

In a preferred embodiment, throughout the radial expansion process, the standoffs 260a-260h prevent the exterior surface of the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is preferably substantially centered within the wellbore 100. Furthermore, in this manner, the longitudinal center axis of the expansion cone 220 is preferably maintained in a position that is substantially coincident with the longitudinal center axis of the tubular member 250. In addition, in this manner, the stresses applied to the interior surface of the tubular member 250 by the axial displacement of the expansion cone 220 are substantially even. Finally, in this manner, overstressing of the tubular member 250 is prevented thereby eliminating catastrophic failure of the tubular member 250.

As illustrated in Fig. 7, the shoe 240 may then be removed using a conventional milling device.

In a preferred embodiment, upon radially expanding the expandable tubular member 250, the standoffs 260a-260h seal and isolate intervals within the open hole section 115. In several alternative embodiments, the standoffs 260 may be provided, for example, by annular members spaced along the length of the expandable tubular member 250 and/or a continuous member that is wrapped around the expandable tubular member 250 in helical fashion.

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the apparatus 200 may be used to form and/or repair, for example, a wellbore casing, a pipeline, or a structural support.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion cone within the wellbore;

overlapping a portion of the solid tubular liner with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone proximate the porous subterranean zone.

2. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

positioning a solid tubular liner and an expansion cone within the wellbore;

overlapping a portion of the solid tubular liner with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

3. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

a tubular support member defining a first internal passage;

an expansion cone coupled to the tubular support member defining a second internal passage fluidicly coupled to the first internal passage;

a tubular expansion cone launcher movably coupled to and mating with the expansion cone;

a tubular liner coupled to an end of the tubular expansion cone launcher; and

a shoe coupled to another end of the tubular expansion cone launcher including a valveable passage; and

means for during a radial expansion of a portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.